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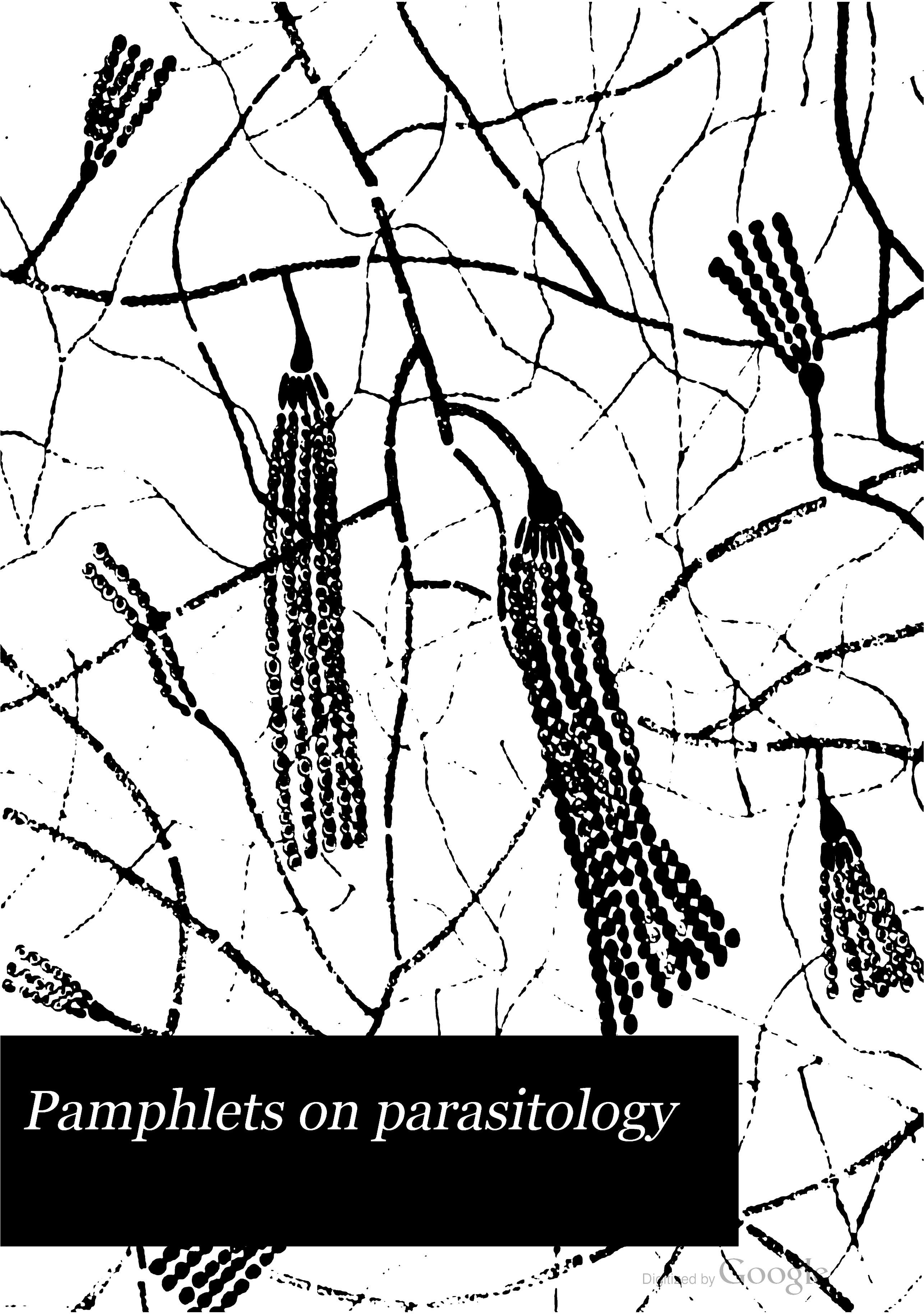

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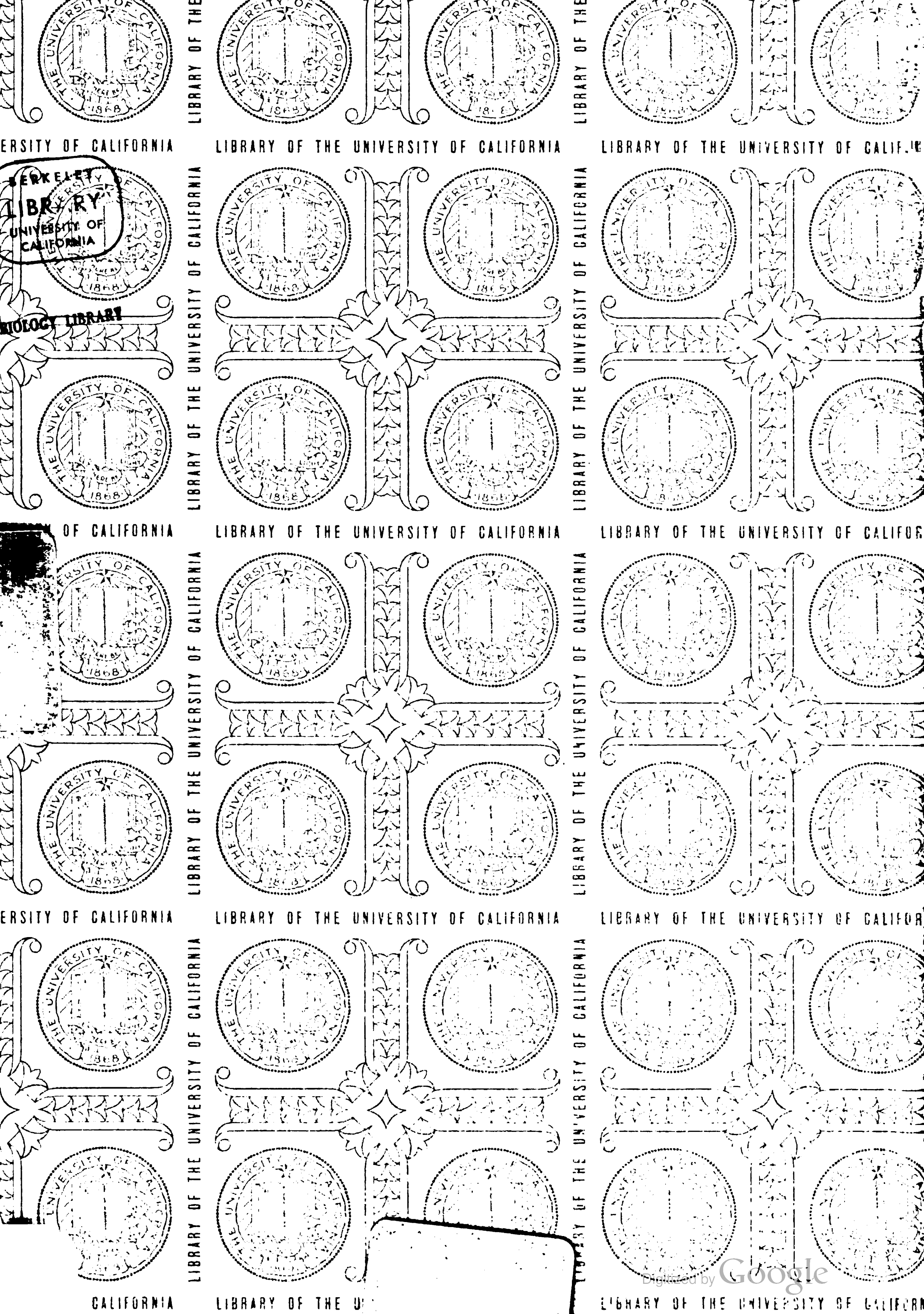
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FACULTÉ DE MÉDECINE DE PARIS

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POUR

E DOCTORAT EN MÉDECINE

Présentée et soutenue le jeudi 27 *octobre* 1898, *à* 1 *heure*

Par J. B. MONTOYA Y FLOREZ

RECHERCHES
SUR LES
CARATÉS DE COLOMBIE

Président : M. DIEULAFOY, *professeur*.
Juges MM. POUCHET, *professeur*.
HALLOPEAU et HANRIOT, *agrégés*.

andidat répondra aux questions qui lui seront faites sur les diverses parties de l'enseignement médical.

PARIS
HENRI JOUVE
IMPRIMEUR DE LA FACULTÉ DE MÉDECINE
15, rue Racine, 15
—
1898

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Le Candidat répon es parties

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A MA PATRIE

A MA FAMILLE

A M. LE D^r R. SABOURAUD

En témoignage de reconnaissance et d'amitié.

A MON PRÉSIDENT DE THÈSE

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RECHERCHES

SUR LES

CARATÉS DE COLOMBIE

INTRODUCTION

Nous suivrons dans cette étude l'exemple d'Alibert et d'Uribe Angel, en décrivant ce que nous avons observé personnellement, sur les *caratés* de Colombie, sans nous préoccuper de ce que d'autres auteurs ont décrit sous les noms de *Pinto*, *Carate*, *Cute*, *Cativi*, *Quirica*, etc., qui s'appliquent, d'après eux, à une même maladie.

Pour nous, nous avons remarqué de nombreuses contradictions, et vu attribuer à cette affection les symptômes les plus discordants, dans les travaux qui considèrent ces dermatoses comme absolument identiques.

En agissant ainsi, nous ne croyons pas augmenter la confusion, et nous espérons laisser les choses à un point où les observateurs qui suivront pourront facilement confirmer la vérité de nos observations, ou relever nos erreurs, et approfondir l'étude de cette curieuse maladie, qui est un large champ ouvert au microscope du Bactériologiste et du Mycologue.

Nos recherches ont été faites dans le département d'Antioquia, où prédomine l'espèce violette du *caraté*, avec toutes ses variétés, violet cendré, violet bleuâtre, violet brun et violet rougeâtre, qui se montre souvent accompagnée de tâches achromiques, articulaires ou non. Les autres espèces de *caraté* y sont relativement rares.

Nous avons pu prendre les observations de cinquante sujets, (dont vingt-quatre citées à la fin de ce travail), atteints de *caraté*, faire l'examen de leurs squames, et donner ainsi à notre étude de l'étiologie de la maladie un développement important et une base sérieuse.

Cette entreprise, qui paraissait à première vue banale, s'est montrée, en réalité, une œuvre complexe et ardue, parce qu'au lieu d'un seul *caraté,* nous nous sommes trouvés en présence de plusieurs *caratés*, à caractères cliniques différents, et se séparant, non seulement par leur couleur, mais par leur marche, leur symptomatologie, leurs complications, le mode de contagion et le pronostic.

Chaque forme clinique est produite par une moisissure, morphologiquement et héréditairement distincte.

Ainsi, par exemple, le *caraté* bleu et le noir violacé sont dûs, chacun, à une espèce différente d'*Aspergillus*. Dans le *caraté* polychrome, chaque tache donne une espèce d'*Aspergillus* en rapport avec sa couleur, et, sur un même « caratejo » (Tel est le nom donné, dans le pays, aux malades porteurs de cette affection), on peut en trouver deux et même trois espèces.

Ces champignons vivent côte à côte, et sans se mêler, bien que le contraire ait lieu parfois, et produise de véritables associations mycosiques.

Les différentes formes de *caratés* nous offrent toute une série de moisissures aspergilloïdes, absolument identique à la série, bien connue aujourd'hui, des *Trichophytons* de Sabouraud.

Comme on le voit, nous nous éloignons ici de la conception de M. Gastambide, d'après laquelle le *pinto* du Mexique est produit par un champignon, toujours le même, dans toutes les squames que l'on examine, et dont l'aspect est celui d'une « cerise attachée à sa queue ». Le mycélium est court et jamais dichotomique.

Dans les centaines de préparations de *caraté*, (environ 2000) que nous avons examinées, jamais nous n'avons vu un champignon présentant la forme d'une cerise, et les mycéliums étaient toujours dichotomiques et très longs.

Il est probable que le champignon découvert par M. Ruiz y Sandoval se rencontre dans quelques formes de *pinto*, fréquentes au Mexique, mais que d'autres formes sont produites par d'autres moisissures. Mais la détermination de la famille à laquelle peut appartenir ce champignon, est impossible, d'après les rares données que transcrit M. Gastambide. Des recherches nouvelles, plus approfondies, peuvent seules établir si Ruiz, a raison, et si l'on retrouve dans quelques *pintos* du Mexique, les *Aspergillus* des *caratés* de Colombie.

Avant d'aborder notre sujet qu'il nous soit permis d'exprimer ici, à M. le Dr Sabouraud, toute notre reconnaissance, pour la si cordiale et si large hospitalité qu'il nous a offert dans son Laboratoire. Nous avons pu y compléter et y perfectionner nos travaux sur les *caratés*, en suivant ses judicieux conseils et ses savantes indications, que sa connaissance étendue et sa grande expérience de la mycologie médicale nous rendaient si précieux.

Nous prions M. le professeur Dieulafoy de vouloir bien accepter tous nos respectueux remerciements, pour l'honneur qu'il nous a fait en voulant bien accepter la présidence de notre thèse.

HISTORIQUE

D'après le R. P. Juan de Velasco, le caraté aurait été importé en Colombie, par des esclaves noirs d'Afrique. « Dans aucune partie du département de Cauca, il « n'y a tánt de caraté, que dans le district du Patia. Il y « fut apporté par des nègres d'Angola, dont la race est « facilement sujette à cette affection, ainsi du reste que « quelques blancs et métis, tandis que les indiens y sont « relativement très rebelles (1). »

M. le Dr Uribe Angel, de Medellin (2) est de la même opinion. Voici ce qu'il en dit : « La laide maladie dont je « parle n'est pas originaire d'Amérique. Les indiens ne « la connaissaient pas, et elle fut importée peu après la « conquête, par une bande de nègres d'Angola, amenés « pour l'exploitation des mines d'or du Patia ».

Plus loin, dans un appendice à son article, le même auteur ajoute les détails suivants : « Les historiens de la « découverte et de la conquête de l'Amérique ne parlent

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1. Juan de Velasco. *Historia del Reino de Quito*, 1789.

2. Uribe Angel. *Observaciones sobre el carate « El Indice »* de Medellin 1867.

« pas de l'existence du caraté, dans les contrées qu'ils « visitèrent et étudièrent dans leurs voyages, et qu'ils « colonisèrent ensuite, pour s'y établir. Un tel silence « prouve que les indigènes de l'Amérique ne connurent « pas la maladie, et n'en souffrirent pas. Car, pour d'au« tres maladies, telles que les « bubas », ils furent au « contraire explicites et clairs.

« M. Vicente Restrepo, chercheur infatigable, sur cer« tains points de notre histoire, dit que le caraté a été « vu, sur des indigènes qui habitaient la partie orientale « de la cordillière, où se trouve la ville de Bogota. Mais « je croirais, sinon qu'il y a ici une erreur, au moins que « le fait a besoin d'être confirmé.

« Au commencement de ce siècle, le Dr Francisco Zea, « un des hommes dont la science et la littérature font « grand honneur à la Colombie, publia, le premier, en « Europe, dans un livre précieux sur la Colombie, sa « géographie et son histoire, une courte notice sur le « caraté, comme maladie intertropicale. »

Après le travail de Zea, Rayer donna une courte description du caraté, dans son ouvrage sur les maladies de la peau.

En 1829, Alibert fit paraître dans la *Revue médicale*, T. XXIII, une description du caraté de Colombie, en partie d'après l'article de Zea, de Medellin, et les données que lui fournirent Bompland, Daste et Roulin, qui avaient voyagé dans ce pays, et y étaient restés un certain temps, mais en se basant surtout sur l'observation personnelle d'un chirurgien colombien, atteint de caraté, et qui consulta à cet effet le grand dermatologiste.

Nous ferons remarquer que, non seulement Alibert traita plus à fond, et étudia mieux le caraté que ses prédécesseurs, mais encore, que l'esprit clinique, dont il était si particulièrement doué, le porta à consigner simplement les faits qu'il avait vus, évitant ainsi d'associer, dans une même description, les symptômes et particularités du *pinto* du Mexique, auquel il ne fait même pas allusion.

En 1867, M. le Dr Uribe Angel publia dans « *El Indice* », de Medellin un article intitulé « Observations sur le caraté ». Comme cet excellent travail n'a trait qu'au seul caraté du département d'Antioquia, nous lui ferons de fréquents emprunts.

La supériorité de la description d'Uribe, est due à ce que, comme Alibert, il nous fait un tableau d'artiste, en quelque sorte, du caraté qu'il a sous les yeux sans se préoccuper des travaux plus ou moins analogues publiés dans d'autres pays.

En 1879, M. le Dr Gomez, dans sa thèse inaugurale de la faculté de Paris (*Du Carathès*), étudie les espèces de caraté, qui prédominent dans le département de Boyaca. Mais, partisan convaincu de l'unité du genre caraté, il le confond dans une même description, après quelques hésitations, avec le *pinto* du Mexique, décrit par Chassin, et le *cute* fébrile du Vénézuéla, décrit par Freitez.

ÉTIOLOGIE

CONDITIONS PRÉDISPOSANTES.

Les caratés sont, en général, endémiques dans les contrées d'une température moyenne de 18° C. à 30° C., marécageuses, ou situées à proximité d'une rivière, ou d'une lagune, pas trop élevées au dessus du niveau de la mer, accidentées et montagneuses, entourées de broussailles et de forêts vierges plus ou moins étendues, et infestées de moustiques avides du sang de l'homme. Sur les bords des grands fleuves, des espèces de cousins appelés « gegenes » (G. *Simulium*) et « zancudos » (G. *Culex*) forment dans l'air des nuages immenses. On y trouve aussi, en abondance, plusieurs espèces de punaises, (G. *Acanthia*). Ces divers insectes jouent un rôle très actif, dans la transmission des caratés.

Les sources minérales, surtout celles qui sortent des galeries souterraines des mines d'or et d'argent aurifère, et qui contiennent toujours des sulfates de fer, de cuivre, et même de zinc, ont une influence très nette sur l'apparition du caraté violet des extrémités, et surtout des pieds, ce qui s'explique, d'abord par le fait qu'elles irritent et crevassent la peau, et en second lieu, parce que les champignons qui produisent le caraté, y trouvent un milieu naturel de culture. Cela nous explique aussi pourquoi, dans certaines mines, de température basse, 10° à 15° C. où il y a peu de moustiques, et où l'on ne trouve pas de punaises, un grand nombre de travailleurs qui marchent nu-pieds dans ces eaux corrosives, présentent souvent des taches de caraté violet-rougeâtre ou rouge pur, formes qui commencent ordinairement par les pieds et produisent ensuite une achromie des régions malléolaires.

Comme règle générale, on peut dire que toute mine dont la température varie entre 18° C. et 30° C. est un foyer important de caraté, avec prédominance de la variété violette, sous toutes ses nuances, et s'accompagnant d'une achromie précoce des régions articulaires.

Les vents froids et secs en desséchant la peau, qui se crevasse, prédisposent dans les climats froids au caraté rouge ou violet rougeâtre.

Dans les climats chauds, l'action d'un soleil brûlant, le frottement des broussailles sur la peau des jambes et des avant-bras qui est habituellement découverte, chez les péons adonnés au rude travail des champs, sont des causes qui diminuent la résistance et la vitalité de la peau, préparent, pour ainsi dire, le terrain, et les spores du champignon pathogène, inoculées par un moustique ou un autre insecte, germent et se développent dans les eilleures conditions.

Les journaliers des établissements agricoles, comme ceux des factoreries minières, sont nourris de viandes salées, et plus ou moins vieilles, de haricots rouges, de pain de maïs, de plusieurs espèces de bananes comme légumes, de sucre non raffiné et d'une purée de maïs avec de la cendre appelée « mazamorra ». Cette nourriture fatigue à la longue le système digestif. Les dilatations d'estomac sont très fréquentes, et les fermentations gastro-intestinales produisent des substances nocives, qui, absorbées, sont éliminées par la peau, en l'irritant et en affaiblissent sa force de résistance déjà bien éprouvée par l'accroissement exagéré de ses fonctions physiologiques, sous un climat embrasé, où l'on transpire toujours.

C'est une croyance populaire que les viandes d'iguane, de lion rouge, en général, les viandes provenant de la chasse des animaux particuliers aux forêts qui entourent les grands fleuves des régions torrides, produisent les caratés. Probablement les graisses fermentées de ces viandes s'éliminent par la peau, comme l'huile rance du maïs et l'irritent en la prédisposant aux caratés. Certains condiments, très employés sous les tropiques, comme les piments, ont un effet analogue.

Les gens les plus exposés sont les péons des « haciendas de terres chaudes », ceux des mines, les muletiers, les bateliers, et, en général, tous ceux que leur métier expose fréquemment aux rayons du soleil, aux traumatismes, divers et répétés, par les broussailles, les cailloux tranchants des ruisseaux des mines, et surtout aux piqûres des moustiques du genre *Simulium*, connus sous le nom de « gegen » ou « mosquitos ».

Il n'existe pas d'immunité de race ; mais on remarque que les sujets de sang pur semblent moins éprouvés par les caratés. Les blancs de race pure, les indiens autochtones et les nègres du plus bel ébène peuvent être atteints, mais ne le sont qu'exceptionnellement, et seulement quand ils ont été longtemps soumis aux causes prédisposantes, ou ont habité longtemps les foyers de caratés. Chez les blancs, on le voit, par exemple, chez les « hacendados », les propriétaires des fermes ou « haciendas » d'engraissage de bétail, situées sur les bords des rivières des régions chaudes, qui s'exposent au soleil ; ou chez ceux qui travaillent eux-mêmes dans les pâturages, se livrent à la chasse ; ou encore, chez les blancs qui exercent la profession de muletiers, et parcourent à pieds nus, souvent sous un soleil brûlant, une grande étendue de territoire. Le caraté qui affecte les blancs qui s'exposent ainsi, est le violet bleuâtre ou rougeâtre. Le caraté rouge pur est surtout une maladie urbaine, de l'ombre, et se rencontre chez les gens d'une certaine aisance, blancs ou métis.

Les caratés qui atteignent les noirs de race pure, sont le caracté noir-encre de Chine, et le caraté blanc vrai, seuls ou associés, maladies cliniquement et mycologiquement différentes des autres caratés, qui semblent autochtones, tandis que les caratés noir et blanc seraient importés et exotiques. Les nègres de race légèrement mêlée, sont bien plus prédisposés que tous autres à ontracter les différents caratés, et spécialement, le noir iolacé.

Les métis des trois races, blanche, nègre et cuivrée, sont le véritable terrain de choix des caratés violets. Chez eux, la maladie se généralise et dure ordinairement autant que le sujet qui en est porteur.

Nous devons faire une exception pour les albinos des races de couleur, qui sont réfractaires à toutes sortes de caratés et peuvent travailler, pendant des années, dans les mines et dans les foyers de caraté, sans qu'ils en soient atteints, même de la variété rouge, qui a une prédilection si marquée pour les peaux blanches.

Les européens sont aussi très réfractaires, et seul un long séjour dans les régions infectées, et la diminution de résistance de la peau par les rayons solaires, ou les eaux sulfatées des mines, peuvent leur faire perdre leur immunité. Il se développe alors une plaque de caraté d'aspect circiné, tricophytoïde, qui reste localisée pendant des années, sans aucune tendance à se généraliser.

Le sexe n'a pas d'influence, et si les femmes s'exposent aux causes qui, chez l'homme, diminuent la résistance de la peau (mulâtresses qui travaillent dans les mines, cuisinières, blanchisseuses en plein air), elles auront vite le caraté qu'elles garderont en général indéfiniment, faute de traitement.

Les caratés font ordinairement leur apparition à l'âge de 15 à 25 ans, époque qui, chez l'homme comme chez la femme, coïncide avec un changement de vie. Les gens du peuple développent, à ce moment, une plus grande activité, se livrent à des occupations plus ou moins pénibles, dans les mines, ou dans les champs de labour et quittent leurs parents, pour vivre de leur propre travail.

Chez les enfants des montagnards, qui se promènent ordinairement nus, au soleil et dans les fourrés, jusqu'à l'âge de 5 à 8 ans, l'apparition des caratés est plus précoce, et l'on peut le voir à l'âge de 8 à 10 ans, exceptionnellement à 3 ou 4 ans. Les vrais caratés cryptogamiques ne sont pas héréditaires et ne se rencontrent pas chez les nouveau-nés.

L'influence des saisons (saison des pluies et été, sous les tropiques) sur l'apparition des caratés, l'aggravation des symptômes ou l'augmentation de la chromogénèse, paraît nulle.

Les mendiants, malgré leur saleté, et leurs vêtements sordides, n'y sont pas plus exposés pour cela, leur paresse les poussant à rester abrités à l'ombre, tandis qu'au contraire, les travailleurs, qui passent la journée au soleil ou dans les eaux des mines, occupés à un travail pénible, y sont plus sensibles, même quand ils jouissent dans leurs foyers d'un certain confortable. Le caraté rouge, dont sont atteints quelques représentants âgés de la classe riche, leur vient de l'époque de leur vie, où ils ont déployé toute leur activité physique et morale, pour se créer une situation.

Les neuf départements de Colombie nous offrent diverses espèces de caratés, dont quelques-unes prédominent dans certaines régions, à l'exclusion des autres.

Le département d'Antioquia passe pour être peu éprouvé. On compte cependant 4 0/0 de la population, en moyenne, comme frappée de la maladie, ce qui représente, pour ce seul département, un total de 20.000 « caratejos » et, pour toute la République colombienne, au moins 200.000.

Dans le département d'Antioquia, il existe des villages à température très élevée, situés à proximité de certains fleuves (le Cauca, le Magdalena, le Porce) et dans lesquels les gens de couleur, qui n'ont pas le caraté, sont l'exception ; les rares blancs qui y demeurent, ont fréquemment, eux-mêmes, ces dermatoses à forme tricophytoïde. Citons dans ce cas, les localités de San Geronimo, Sopetran, Cruces de Caceres, Zaragoza, Remedios, etc.

En résumé, nous compterons comme causes prédisposantes les suivantes :

1° Erythème solaire. Lieux chauds et humides.

2° Frottements et égratignures par les broussailles.

3° Macération de l'épiderme par un séjour prolongé dans l'eau.

4° Action corrosive et *fissurante* des eaux sulfatées et calcaires, et des bains pris habituellement dans les eaux des mines d'or et d'argent.

5° Habitude de travailler, les pieds, jambes et bras nus, et le tronc couvert seulement d'une chemise de coton, largement ouverte sur le devant.

6° Sudation continue, sur une peau malpropre, chez des gens qui changent rarement de linge de corps.

7° Alimentation défectueuse, dont plusieurs substances plus ou moins volatiles, s'éliminent par la peau, en augmentant l'exfoliation épidermique.

8° Croisement et métisage des races.

CAUSES DÉTERMINANTES.

D'après nos recherches, les caratés sont des *dermatomycoses* produites par des champignons à forme *aspergilloïde*, de diverses espèces, et que l'on retrouve, toujours et facilement, à l'examen microscopique des squames épidermiques des caratés, par les procédés que nous allons décrire.

Examen microscopique des squames des caratés.

1° Prendre sur une lame de verre quelques squames minces de caraté.

2° Verser dessus, une goutte de solution aqueuse de potasse, à 40 grammes de potasse caustique pour 60 grammes d'eau distillée.

3° Recouvrir d'une lamelle.

4° Chauffer doucement à la flamme pendant quelques secondes, sans aller jusqu'à l'ébullition.

5° Examiner au microscope, avec un oculaire n° 3 et un objectif n° 7, en fermant presque le diaphragme iris.

Voici ce que l'on aperçoit :

Entre les cellules épidermiques, sont de longs filaments dichotomiques, généralement très fins, lisses, cylindriques, et dans certaines conditions, granuleux, et en chapelet. Dans quelques points, ils forment un réticulum serré comme s'il s'agissait d'une culture artificielle. De ce réseau, on voit sortir des filaments, deux ou trois fois plus gros, véritables câbles composés de deux, trois ou quatre fins mycéliums, que l'on distingue parfaitement, par un léger déplacement de la vis micrométrique de mise au point. Dans d'autres endroits, on voit émerger par dichotomie d'un filament mince, une branche courte et d'une grosseur double. Cette branche se termine, ordinairement, par un fruit relativement volumineux et caractéristique de l'espèce de caraté que l'on examine.

En général, les hyphes, ou tiges courtes fructifères, semblent se terminer par une tête ou renflement piriforme ou triangulaire, couronnée par une seule rangée de cinq ou six stérigmates, qui soutiennent, chacune, un chapelet de 3, 4, ou 5 spores. Ces spores sont deux ou trois fois plus volumineuses que les mycéliums radiculaires, et toujours, de forme sphéroïdale. Quand on vient à faire tourner légèrement la vis micrométrique, on remarque que chaque spore est formé d'un protoplasma, et d'un nucléus plus foncé.

Quand on examine des squames de caratés très vieux, (40 à 60 ans), il arrive que l'on voit seulement des filaments granuleux, excessivement minces, plus ou moins ondulés et d'une longueur extrême. Plusieurs n'ont d'autres limites que celles de la préparation. Ces mycéliums sont toujours dichotomiques et ne portent de fruits que très rarement, et en petit nombre; alors les tiges ou hyphes fructifères sont aussi minces que les mycéliums radiculaires, et le fruit, lui-même, tout en gardant ses caractères, est petit et chétif, comme la dernière pousse d'une plante qui se meurt d'épuisement et de vieillesse.

Dans les écailles des caratés très jeunes, les filaments mycéliens sont très rares, gros, et en général pas très longs, avec des branches dichotomiques courtes, des hyphes grosses, terminées par un renflement en massue ou piriforme, et qui supporte très rarement des spores.

Dans certains endroits on voit des amas de corps en massue ou en raquette, quelques-uns sans connexion apparente avec le mycélium et d'autres, terminés par un court filament qui montre quelquefois un commencement de dichotomie.

Ces amas de corps en raquette ressemblent quelque peu à des cellules cancéreuses. Quelquefois ces éléments ont le volume des noyaux cellulaires, et comme eux, sont plus foncés et prennent mieux les couleurs. Mais on les en distingue facilement par leur polymorphisme, et leur distribution en amas irréguliers. De plus ces corps ne sont pas solubles dans la potasse, comme les cellules animales.

Dans les caratés adultes (10 à 30 ans), les filaments mycéliaux et les fruits complets et caractéristiques de chaque espèce sont très abondants dans les squames.

Tout ce qui précède est spécialement applicable aux caratés : violet, rouge, bleu et noir-violacé.

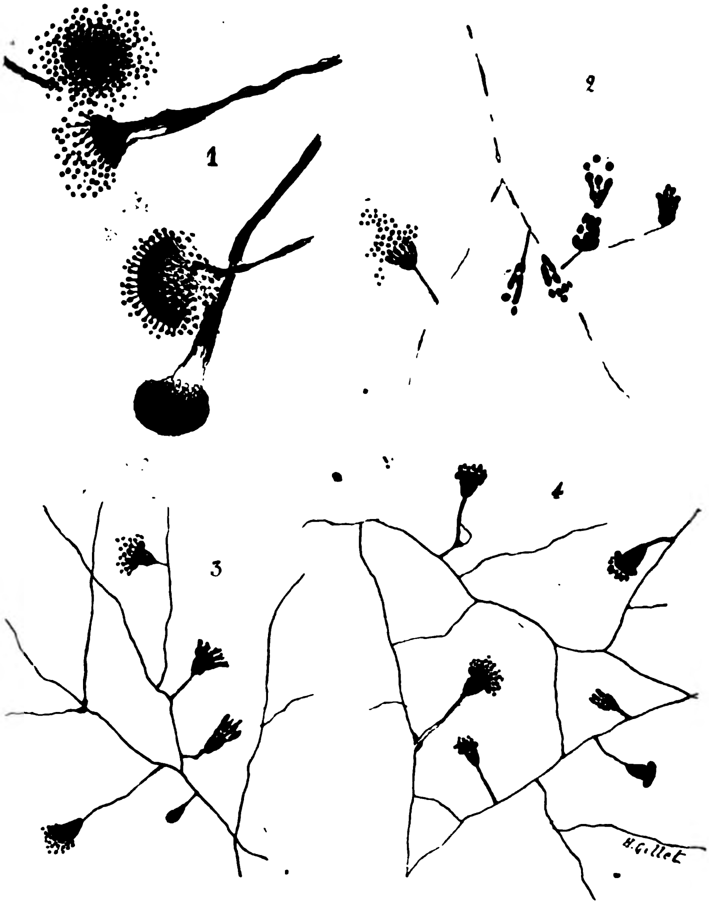

FIG. 1

1. Caraté rouge.
2. Caraté noir-violacé.
3. Caraté violet-cendré.
4 Caraté bleu.

La figure n° 1 nous montre quatre préparations de squames de divers caratés, dessinées à la chambre claire (Oc. III. Obj. 7 Leitz) en ne reproduisant que la végétation cryptogamique avec ses fruits. Elle nous fait voir, réunies sur une même planche, pour mieux faire ressortir la différence des espèces, les fruits et les spores des quatre principaux caratés avec leur aspect caractéristique.

MÉTHODES DE COLORATION.

1° Placer les squames sur un verre de montre.

2° Verser un peu d'ammoniaque, et laisser quelques minutes pour dégraisser.

3° Retirer l'ammoniaque; verser un peu d'acool saturé d'acide picrique, et ajouter 4 à 5 gouttes d'acide acétique.

4° Laisser cinq minutes; puis laver à l'eau distillée, (mais ce lavage n'est pas indispensable).

5° Monter à sec ; placer, sur la lamelle couvre-objet, une deuxième lame de verre et, en appuyant la préparation sur la table, presser avec les doigts, en faisant glisser la lame supérieure pour dissocier les squames. Quand ce résultat paraît bien atteint, luter la préparation à la paraffine.

Sur dix préparations faites par ce procédé, on en obtient facilement deux ou trois, qui montrent très bien, les plus fins réseaux mycéliaux. Elles sont excellentes pour la photographie.

Le défaut de ce procédé est de ne montrer que les mycéliums, parce que les fruits sont souvent abîmés par le glissement et la pression, bien qu'avec une certaine habitude, on arrive à avoir des fruits complets.

L'acide picrique agit en durcissant le mycélium, qui est parfois très fragile, et se réduirait en fines granulations.

L'acide acétique fixe et durcit les fruits avec leurs spores.

Ces préparations doivent être examinées en fermant un peu le diaphragme. On voit ainsi bien mieux les détails. L'emploi de la lumière artificielle est préférable.

La figure n° 2 a été obtenue de cette façon. Elle montre le mycélium granuleux, souffreteux, sans fruits, d'un caraté violet-cendré âgé de 40 ans.

Coloration élective au bleu polychrome d'Unna.

1° Choisir des squames minces, que l'on met dans un verre de montre.

2° Dégraisser à l'éther.

3° Verser un peu d'alcool absolu, avec 5 à 10 gouttes d'acide acétique cristallisable. Laisser cinq minutes.

4° Laver abondamment à l'alcool absolu.

5° Bien égoutter, et verser dans un demi-verre d'eau filtrée, 2 ou 3 gouttes de bleu polychrome.

6° Laisser dans le bleu, de cinq à dix minutes.

7° Laver à l'alcool absolu, jusqu'à ce que celui-ci sorte incolore ;

8° Passer au xylol, pour éclaircir ;

9° Monter au baume du Canada, dissous dans le xylol.

Cette méthode de coloration donne les meilleurs résultats. Les filaments mycéliaux et les fruits prennent également très bien le colorant. De plus, l'acide acétique durcissant et fixant les spores, on voit les fruits complets. C'est ainsi qu'a été obtenue la préparation de la fig. n° 5 qui représente une squame de caraté violet-bleuâtre, en plein développement. Cet aspect du mycélium et des fruits est pour ainsi dire, le type général des autres caratés.

Double coloration.

1° Faire subir aux squames du caraté toutes les manipulations indiquées dans le procédé précédent, jusqu'au septième temps, inclusivement.

2° Verser sur les squames un demi-verre de montre d'alcool absolu, et ajouter une à deux gouttes d'alcool picrique saturé.

3° Laisser une à deux minutes;

4° Laver abondamment à l'alcool absolu;

5° Bien passer au xylol;

6° Monter au baume.

Les préparations ainsi obtenues sont très démonstratives; le mycélium et ses fruits sont colorés en bleu, tandis que le fond est coloré en jaune pâle. Mais c'est un procédé délicat, parce que l'acide picrique, en excès, précipite en flocons le bleu polychrome. La préparation présente alors une teinte vert émeraude uniforme et est complètement floue.

Coloration à la thionine.

1° Dégraisser à l'éther ;

2° Laver à l'alcool absolu ;

3° Verser dans un demi-verre de montre d'eau distillée filtrée, deux à trois gouttes de thionine phéniquée de Nicolle, et bien mélanger ;

4° Laisser de cinq à vingt minutes ;

5° Laver à l'alcool absolu, jusqu'à ce qu'il n'entraîne plus de bleu ;

6° Eclaircir au xylol ;

7° Monter au baume, et conserver à l'abri de la lumière.

Un procédé qui donne de meilleurs résultats, consiste à laisser les squames dans une solution aqueuse très diluée de thionine, pendant 12 à 24 heures, sous cloche humide pour éviter l'évaporation. On obtient ainsi d'aussi belles préparations qu'avec le bleu d'Unna. Mais, elles finissent à la longue par se décolorer, surtout si on ne les met pas à l'abri de la lumière.

Autres colorants.

Le bleu boraté, employé de la même façon que la thionine, donne de bons résultats, et les préparations se gardent bien.

Les solutions aqueuses diluées, et légèrement chauffées de violet de gentiane et de dahlia colorent quelques mycéliums.

Les couleurs rouges ne conviennent pas aux champignons des caratés.

Le Gram ne les colore que d'une manière très irrégulière en général.

Disons en terminant que les préparations coloriées de caraté noir-violacé montrent de longs, mais très rares filaments, tandis que celles des caratés violets, rouges et bleus, ont un réseau mycélien très abondant. Les cellules épidermiques, dans le caraté noir-violacé sont recouvertes par une abondante poussière poisseuse, ou cireuse, de couleur brune.

MILIEUX DE CULTURE

Celui qui convient le mieux aux champignons des caratés est la gélose peptonisée, glycérinée à 4 0/0. Après, vient la gélose au moût de bière.

Les milieux doivent être légèrement acides, et on ne doit pas les alcaliniser au carbonate de soude. Il est aussi inutile d'ajouter un acide quelconque.

La pomme de terre est aussi un bon milieu.

Tous les champignons aspergilloïdes des caratés se développent très bien sur la gélose, à 1/1000 de sulfate de fer, de cuivre, ou même de zinc, comme pouvaient du reste le faire prévoir les conditions de développement des caratés chez les mineurs.

Le liquide de Raulin n'est pas supérieur aux milieux glycérinés, et même, quelques champignons y poussent mal, ou ne poussent pas du tout.

Pour les cultures en goutte suspendue, le meilleur est le bouillon peptonisé glycériné.

Température des cultures.

Les cultures des caratés poussent très bien entre 30° et 35° centigrades, plutôt 30° C; jusqu'à 40° C. ils poussent encore, mais moins bien. Au delà de 40°, ils commencent à péricliter et restent stationnaires. De 15° C. à 20° C. la végétation se fait, mais lentement. Il en est de même de 10° à 15° mais encore plus lentement. De 5° C. à 10° C. les moisissures qui se rapprochent le plus des *Penicilliums*, continuent seules à pousser. Mais le développement des vrais *Aspergillus* est arrêté.

Mode d'ensemencement.

1° Placer sur une lame de verre stérilisée quelques squames de caraté.

2° Les réduire presque en poussière, au moyen de deux aiguilles en fer de lance, passées à la flamme.

3° Prendre de la main gauche un tube de gélose glycérinée, et flamber le bouchon ; de la main droite, armée de la longue aiguille en lance de Sabouraud, (bien stérilisée à la flamme et refroidie) prendre une parcelle de poussière de caraté.

4° Avec le petit doigt de la main droite, replié, prendre le bouchon de coton, en tenant le tube incliné en bas ; introduire l'aiguille, et faire au centre une ligne d'ensemencements successifs, espacés d'un à deux centimètres ; puis à côté, sur les bords, deux autres séries, alternant en quinconce, avec les premières.

5° Flamber l'extrémité du tube et replacer le bouchon ;

6° Laisser à une température de 18° à 25°.

Une température supérieure fait pousser très rapidement les microcoques ou les bactéries saprophytes très abondantes sur la peau des « caratejos » en empêchant l'apparition des colonies cryptogamiques des caratés ; ou, si elles ont commencé à se développer, en les étouffant rapidement, surtout si l'on a placé les tubes à l'étuve à 37°. En été, le procédé de choix est de laisser les cultures se faire à la température du laboratoire.

La purification et le réensemencement des cultures se font comme d'ordinaire sur les géloses, glycérinée ou maltosée.

Quand les colonies cryptogamiques seront pures, on les placera à l'étuve entre 30° et 35° pour obtenir une croissance plus rapide et un développement plus abondant.

Un autre procédé, qui est excellent, pour certains caratés, parce que l'on évite les microbes saprophytes, est celui qui consiste à ensemencer les squames sur des tubes à essai, remplis au quart de liquide de Raulin, en laissant le tout à la température du laboratoire. On peut aussi se servir avec avantage de gélose au liquide de Raulin.

D'une façon générale les colonies de caratés ne commencent à se montrer que du dixième au quinzième jour, ce qui explique pourquoi les saprophytes banaux de la peau (bactéries et champignons) nuisent tant à leur culture.

Les meilleurs caratés pour l'ensemencement sont ceux qui sont en plein développement (10 à 20 ans), parce qu'ils portent énormément de fruits sporulés ; dans ces conditions, on obtient le champignon pathogène pur d'emblée, et dans tous lès ensemencements.

Ordinairement dans les jeunes caratés (1 à 2 ans), il faut ensemencer dix ou vingt tubes d'un coup, pour avoir quelques rares colonies sur trois ou quatre tubes, ce qui paraît dû à ce que les fruits sont en grande partie incomplets, et ne portent pas encore de spores.

Dans les vieux caratés de 40 à 50 ans, c'est un véritable chaos, et en plus des champignons pathogènes, on voit successivement apparaître (même jusqu'au deuxième mois), une série de mucédinées banales, qui vivent en saprophytes sur la peau malpropre des vieillards atteints de caraté, dont beaucoup n'ont pas pris de bains depuis plus de dix ans. On y rencontre encore une douzaine de formes variées de bactéries, de microcoques vulgaires, mais ces micro-organismes ne sont pas pathogènes, pour les lapins et les cobayes, même en injections intrapéritonéales.

Les caratés récents, et les caratés anciens sont donc peu favorables à l'étude.

CARACTÈRES BOTANIQUES

Aspect des cultures. Morphologie.

Caraté violet-cendré.

Les cultures de ce groupe ressemblent comme couleur et comme forme, aux colonies de *Pénicillium*, quand elles sont cultivées sur gélose au moût de bière ou sur gélose peptonisée et glycérinée à 4 0/0, alcalinisée ou non. La couleur définitive en est gris-violacée, et quelquefois violet cendré. La gélose glycérinée se colore légèrement en rose.

La culture présente un aspect laineux, court, crêpu, et blanc au début. Puis elle prend une teinte glauque, et, finalement violette. Les colonies sont généralement planes, croissent rapidement, au point de couvrir, en peu de jours, toute la surface du milieu nutritif. Les cultures vieilles présentent des mamelons rosés ; en plus la membrane mycélienne adhérente à la gélose glycérinée prend une teinte rosée.

Dans le bouillon glycériné, il se forme une bourse irrégulière dont le fond présente une multitude de tubercules lisses et blanchâtres, et le bouillon prend la couleur jaune de l'acide picrique.

Des squames du même caraté violet-cendré, mais provenant de localités différentes, donnent des colonies saillantes, d'une couleur pâle, lisse et d'aspect humide. Avec le temps, elles se couvrent d'un duvet court, frisé, et de couleur violette. La culture sur bouillon glycériné prend le même aspect que celui déjà décrit, et le liquide se colore en jaune. Les champignons qui donnent ces cultures se rapprochent du genre *Penicillium*.

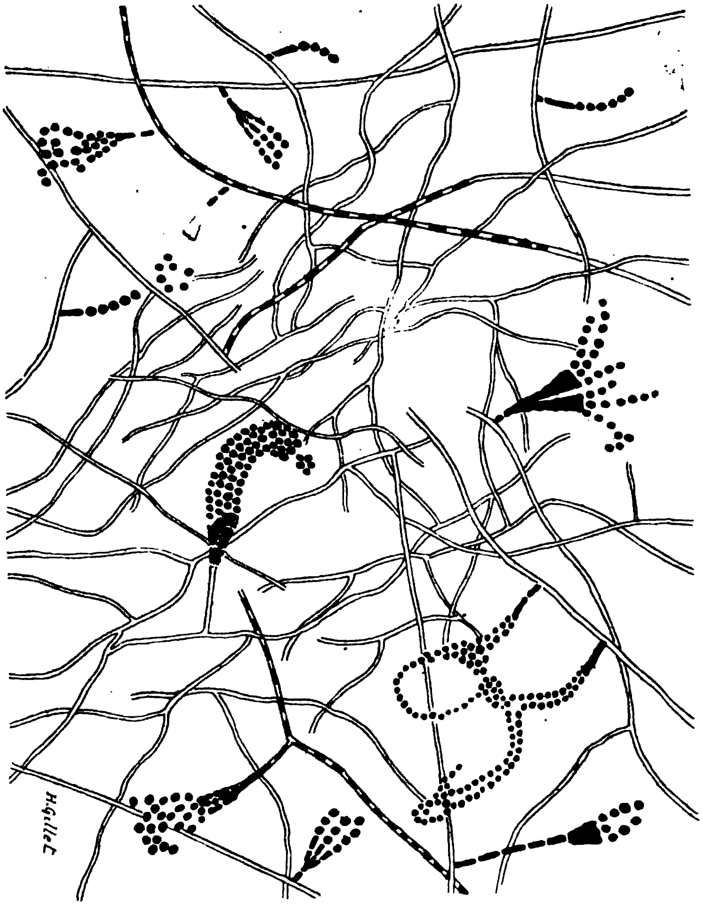

Fig. 1 *bis*.

Culture de 10 jours d'un caraté violet-cendré de Remedios, dessiné avec Oc. III, et Obj. 8 Verick.

Nous venons de donner les caractères macroscopiques des cultures. Nous allons en décrire maintenant la morphologie microscopique.

Nous trouvons ici un mycélium radiculaire rampant et plus ou moins granuleux ; des filaments courts plus gros, portant des pinceaux de spores lisses. Ces chapelets de spores se dissocient avec une grande facilité, et le fruit devient méconnaissable, ce qui n'arrive pas pour les vrais *Aspergillus*, dont les fruits sont plus fermes, et dont il reste toujours la tête, avec quelques spores. En tous cas c'est la forme des caratés, qui se rapproche le plus des *Penicilliums*, et nous la donnons sous toutes réserves.

La figure n° 1 *bis* représente une culture de dix jours, en goutte suspendue, d'un caraté violet-cendré, provenant des mines de Remedios. Elle a été dessinée, d'après nature, avec l'oculaire III et l'objectif n° 8 de Vérick. On ne voit que des filaments fertiles assez gros, avec de courtes hyphes sporifères, portant des fruits à plusieurs degrès de développement.

La figure n° 2 représente une squame épidermique dissociée du même caraté, colorée à l'acide picrique. On voit un fin réticulum de mycélium radiculaire stérile. Les filaments sont granuleux et d'une extrême finesse. Il n'y a pas un fruit. Sur plus de 200 préparations de ce caraté, il ne nous a été possible de voir que quelques fruits chétifs et déformés. Le fait s'explique par la longue durée, (quarante ans) de la maladie, le champignon ne produisant plus de fruits quand il est très vieux ; et peut-être aussi, parce que les manipulations de la coloration abîment le peu de fruits qui restent dans ces formes pénicilloïdes, qui sont très délicates et se dissocient avec ne extrême facilité.

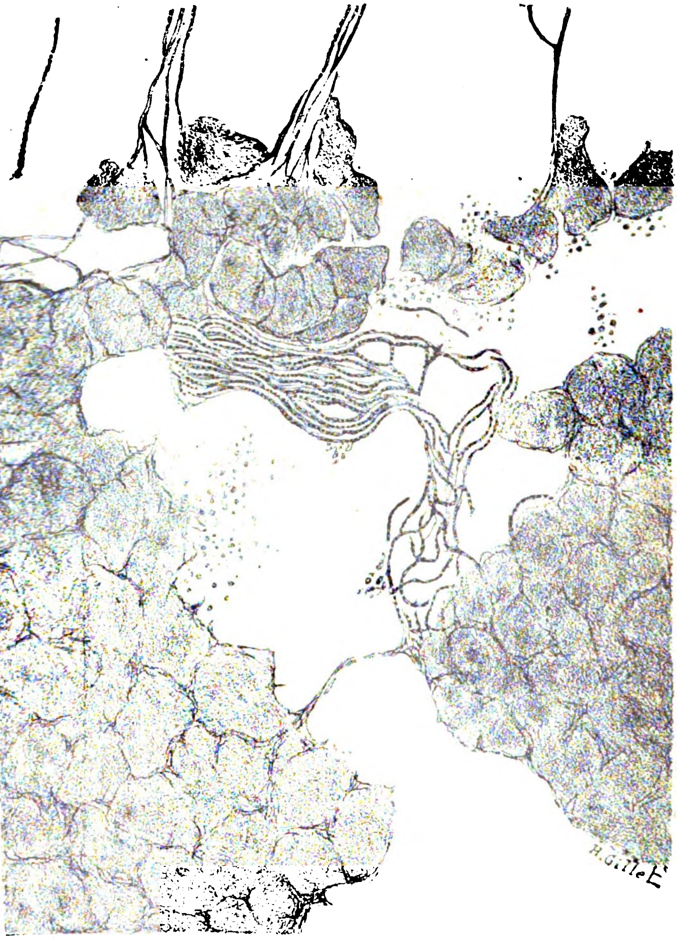

FIG. 2

Squame épidermique d'un caraté violet-cendré datant de 40 ans.
Oc. III. Obj. 8 Verick.

Caraté violet pur.

Ce groupe nous a paru, jusqu'à présent, exclusivement produit par diverses espèces ou variétés d'*Aspergillus* typiques. Les colonies, au début, sont lisses, d'une couleur pâle; puis, elles se couvrent, au centre, d'un duvet blanc, à filaments raides, qui envahit plus tard toute la colonie qui passe alors, en entier, à la couleur glauque, en commençant par le centre. La nuance finale est violette.

Dans certaines occasions, sur la gélose glycérinée, les colonies à duvet blanc deviennent rosées et couvrent tout le milieu, en conservant cette couleur, et en formant un tapis ondulé qui fendille la gélose, et la teintent en rose. Ces cultures, d'un rose couleur de chair, se couvrent en partie de petits points verts discrets. Sur le bouillon glycériné, il se forme à la partie supérieure une bourse irrégulière et sinueuse qui se recouvre d'une poudre violacée, et le liquide devient couleur de caramel.

Les colonies de ces *Aspergillus* varient de couleur selon la composition du milieu où on les cultive.

Des caratés violets, d'autres provenances, donnent une culture qui, blanche au commencement, devient ensuite verte, et en s'étendant, forme des plis un peu saillants. Cette couleur verte est très persistante. Chez les vieilles cultures elle est remplacée par une couleur vert sombre.

La gélose glycérinée devient couleur caramel.

Les colonies de cet *Aspergillus* ne changent pas de couleur, selon les différents milieux.

Certains autres caratés donnent des colonies d'un blanc d'hermine, saillantes et ondulées, qui se couvrent, par la suite, de petites sphères roses, vertes, ou glauques, de façon à présenter l'aspect d'une lame de cuivre chauffée au feu. En général, la teinte rose prédomine. Cet aspect est constant et définitif, et non pas occasionnel, et dû à un simple pléomorphisme. Ce champignon donne à la gélose glycérinée une couleur de gelée de groseille.

En plus il peut prendre un aspect pléomorphe différent, et, dans ce cas, les colonies sont composées d'un duvet gros, d'un blanc de sucre ou de cristal, et d'un aspect humide et lisse. En vieillissant, elles sèchent et se teintent en rose. La morphologie est celle qu'indique la gravure ci-jointe.

La figure 3 représente une culture en goutte suspendue, âgée de dix jours, provenant d'un caraté violet hyperkératinisant, des mines de chaux d'Armenia. Le grossissement est le même que précédemment. On voit de minces filaments rampants, plus ou moins cloisonnés, dichotomiques et très longs, qui s'épaississent subitement et donnent naissance à des hyphes très grosses et très fortes, terminées par une tête volumineuse entourée partout de chapelets de spores lisses très petites et presque sans protoplasma. On voit de plus quelques états incomplets de fructification, et de courts stérigmates, disposés sur une tête qui ne porte pas encore des spores. Certains mycéliums radiculaires s'enroulent en spire, formant une ébauche de périthèque. Les hyphes sporifères sont lisses et non cloisonnées.

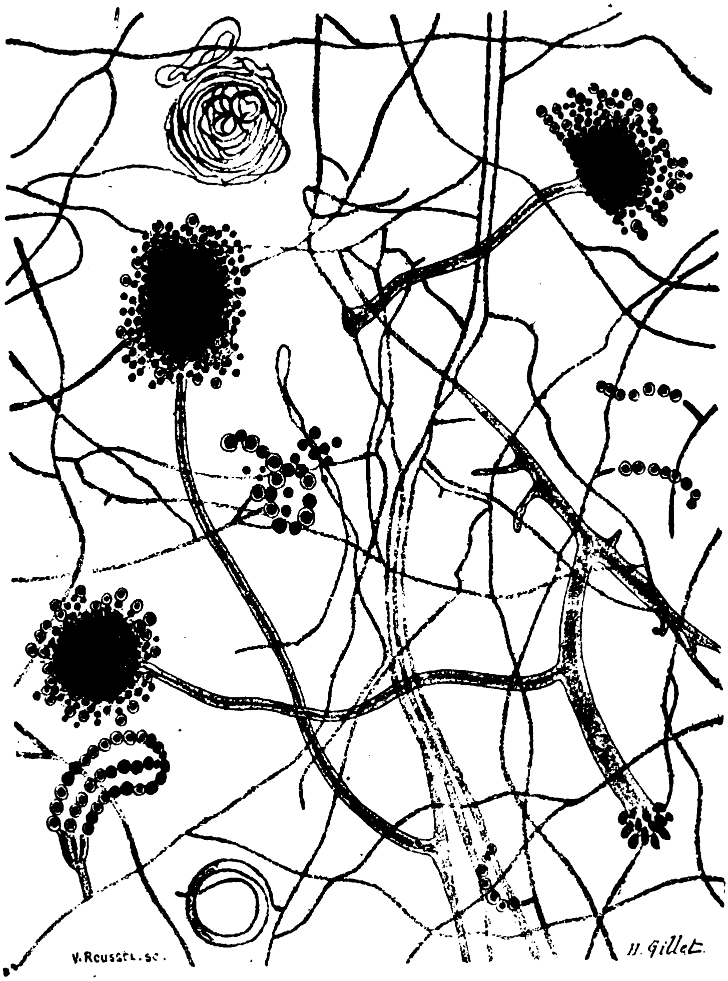
V. Roussel. sc.
H. Gillet.

Fig. 3

Culture de 10 jours en goutte suspendue d'un caraté violet des mines de chaux d'Armenia.

Caraté violet-bleuâtre.

Les colonies sont ici d'une couleur vert glauque, en général dès le début, qui persiste dans tous les milieux et ne change presque pas en vieillissant.

Ces colonies se développent et s'étendent lentement, en formant des collines très saillantes et ondulées, et dans quelques occasions, des plis lisses, jaunes, favoïdes. La gélose ne se colore pas.

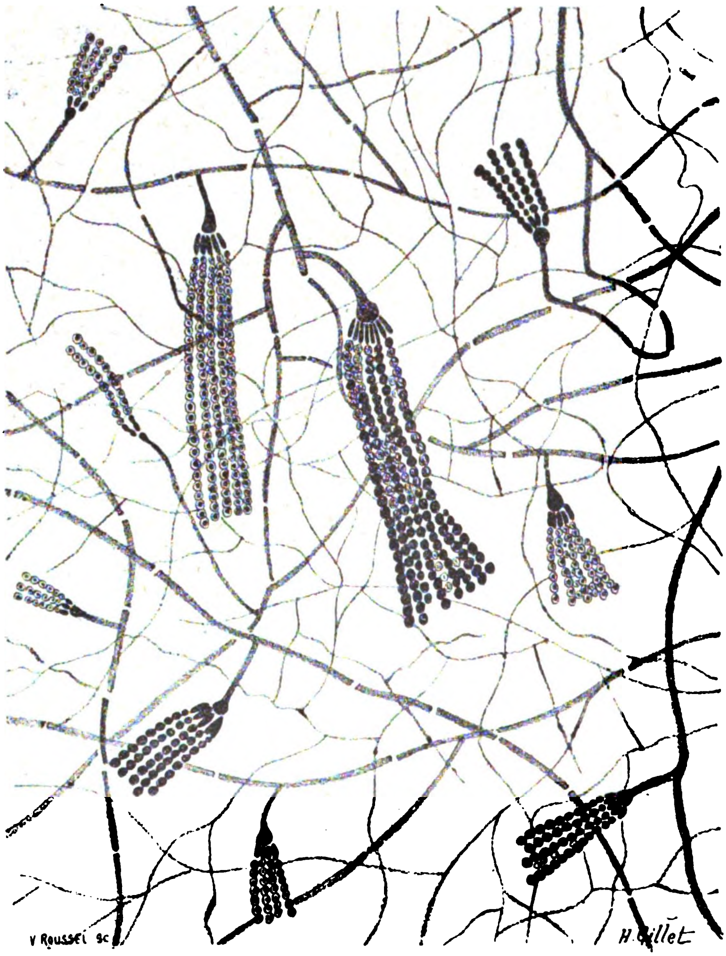

Fig. 4

Culture de 20 jours en goutte suspendue, provenant d'un caraté violet bleuâtre de Quebraditas.

Dans le bouillon glycériné, ce champignon produit une bourse de fond irrégulier et fissuré. Le liquide ne se teinte pas.

A la partie supérieure du verre se dépose une poudre verte, très fine, en même temps que se développe un réseau de très minces filaments. Cette catégorie de cultures provient d'un des caratés les plus fréquents de tout le département d'Antioquia.

Ce champignon est une espèce intermédiaire entre les *Penicilliums* et les *Aspergillus*, mais, plutôt, un *Aspergillus*, d'après l'opinion du professeur Van Tieghem.

La figure n° 4 représente une culture de 20 jours, d'un de ces caratés provenant de Quebraditas. On voit de longs filaments de mycélium radiculaire, profusément dichotomiques. Sur eux et plus superficiellement, des filaments fertiles, plus gros et articulés, ou séparés par des stries, qui ne prennent pas la couleur. Ces filaments supportent des hyphes, terminées par une tête petite, triangulaire ou piriforme, munie d'une rangée de stérigmates, qui soutiennent des chapelets, très longs sur les fruits adultes, de spores lisses nucléées, et munies d'un protoplasma très apparent. Ces spores sont placées en files parallèles, de façon que l'ensemble forme un paquet rectangulaire dans les fruits adultes. Mais, dans les petits fruits divergents à l'extrémité finale. ils offrent plutôt l'aspect d'un triangle. Il est à remarquer qu'à mesure que les cultures sont plus vieilles et les fruits plus développés, la tête devient plus grosse, et le fruit acquiert d'une façon nette l'aspect d'un *Aspergillus*. La figure n° 5 représente une squame épidermique du même caraté. Le développement des fruits reste incomplet sur la peau, mais ils sont parfaitement reconnaissables. Il faut noter aussi que les fruits sont plus solides et résistent très bien aux manipulations pour les colorer.

Sur les squames, on voit beaucoup de corps triangulaires qui ne sont que le support basidial des spores qui n'ont pas encore poussé.

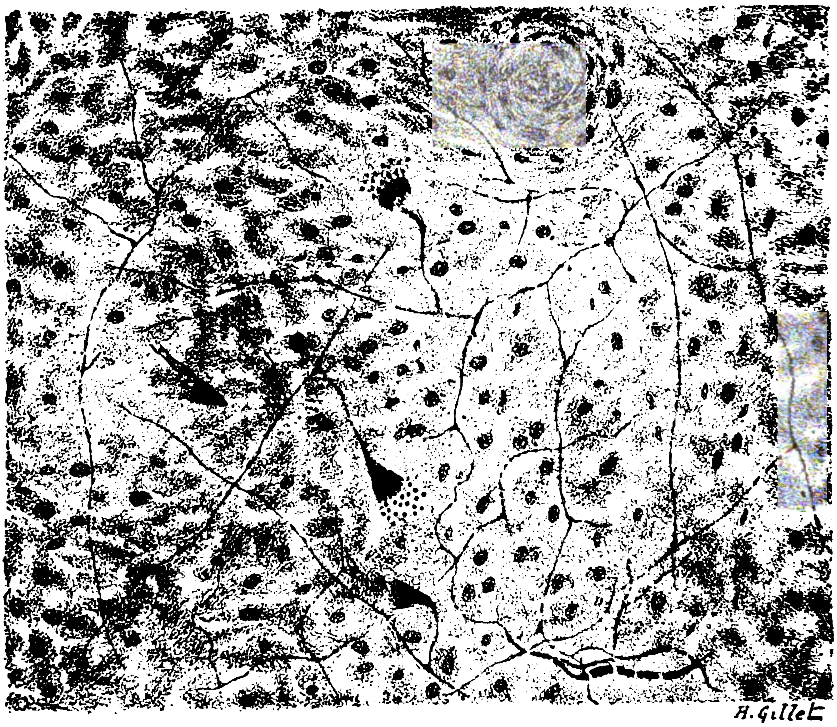

Fig. 5

Squame épidermique d'un caraté violet-bleuâtre provenant de Quebraditas.

Caraté violet-brun.

Les colonies de ce caraté sont brun clair ou amadou, dès le début, et la couleur persiste dans tous les milieux et d'une façon indéfinie. Elles sont en relief et constituent des colonies cérébriformes d'accroissement lent. Souvent les vieilles colonies prennent un aspect pléomorphe lisse, jaune, comme les colonies de certains favus; sur la limite du verre et de la gélose, elles forment un velouté long et lisse, qui envahit une partie du verre, et reste ensuite stationnaire. Presque toujours, aux limites de la colonie primitive, en apparaissent d'autres plus petites. Ce caractère est constant et tipique.

La gélose glycérinée, dans les vieilles cultures prend une couleur brune.

Sur le bouillon glycériné, il se forme une bourse régulière, à fond lisse, de couleur brun claire, et dont la partie supérieure se recouvre d'une fine poussière couleur ocre ou brique. Des filaments très fins, presque imperceptibles, envahissent le verre, et le liquide reste transparent et devient rouge foncé. Les vieilles cultures sur bouillon glycériné prennent une couleur brun violet presque noir et le liquide ressemble à de l'encre.

Des colonies de ce champignon peuvent s'associer aux colonies glauques des caratés violet-bleuâtres et produire une culture cendrée ou blanchâtre mixte, et dont il est très difficile d'isoler les deux composants. Ces associations se rencontrent dans la majeure partie des caratés polychromes et un même individu donne des colonies glauques, brunes, et mélangées. Dans certains cas, les colonies glauques forment les 90/100, et le reste est brun. Dans d'autres, la proportion est inverse, suivant la couleur des taches prédominantes dans la forme multicolore ou polychrome des caratés. Les caratés multicolores, qui donnent ces espèces de cultures, sont très fréquents dans le département d'Antioquia.

En goutte suspendue, les cultures ne donnent, même au 30^{me} jour, que des fruits incomplets, en chapelets de grosses spores, comme les *Monilia.* Mais, si l'on cultive le champignon dans un tube à essai sur du bouillon glycériné, un mois ou deux après l'ensemencement, sur la végétation qui se forme sur les parois du verre apparaissent de petites sphères jaunes, qui ne sont autres que des grosses têtes d'un *Aspergillus* typique. Ce fait est très important au point de vue de la classification botanique.

Caraté bleu

Les colonies s'accroissent avec une extrême lenteur ; au début, d'une couleur pâle, elles se couvrent plus tard, d'un vernis bleu, adhérent, qui atteint rarement les proportions d'un duvet court et discret. Ces colonies sont toujours saillantes, plus ou moins acuminées. Les vieilles cultures se couvrent ou se couronnent de replis lisses, jaunes, de couleur vieil ivoire, d'aspect humide et cérébriforme, comme les cultures de certains favus. Cette végétation pléomorphe apparaît à la fin, quand le milieu est épuisé, ou dès le début, quand le terrain est peu approprié. Ce champignon ne secrète pas de pigment dans les milieux de culture.

Les colonies extrêmes, sur la limite de la gélose et du verre des tubes s'étendent sur le verre, en formant une fine poussière glauque, composée entièrement de fruits, couverts de spores très propres à l'ensemencement.

Dans le bouillon, le développement est très difficile, d'une lenteur désespérante, et à la fin, à 35° C. les parois des tubes sont envahies par des filaments très fins, et une poussière fine glauque et assez rare, recouvre la partie supérieure du liquide, mais sans former de bourse.

Ce champignon est un type d'*Aspergillus* à fruits très volumineux, comme le montre la figure n° 6, qui représente une culture de 30 jours, en goutte suspendue. Il est à noter que les têtes très volumineuses portent toujours des spores sessiles, sans stérigmates, sur la face supérieure exclusivement, formant une espèce de couronne qui est invariable et caractéristique. On voit en plus, des fruits jeunes, incomplets, qui montrent le développement d'une rangée de stérigmates volumineux, donnant naissance à des spores et disparaissant complètement, dans le fruit adulte. La figure ne montre que des filaments fertiles très gros. Mais, dans ce champignon, comme dans les autres, les filaments du mycélium radiculaire sont très fins, comme on peut le voir dans la figure n° 7 qui représente une culture semi-aérobie d'une squame de caracté bleu. Les filaments fertiles sont rares et portent des fruits chétifs et incomplets, tandis que le mycélium radiculaire est très abondant. Tous ces filaments sortent de la squame épidermique et ne sont qu'une prolongation de ceux que l'on y voit.

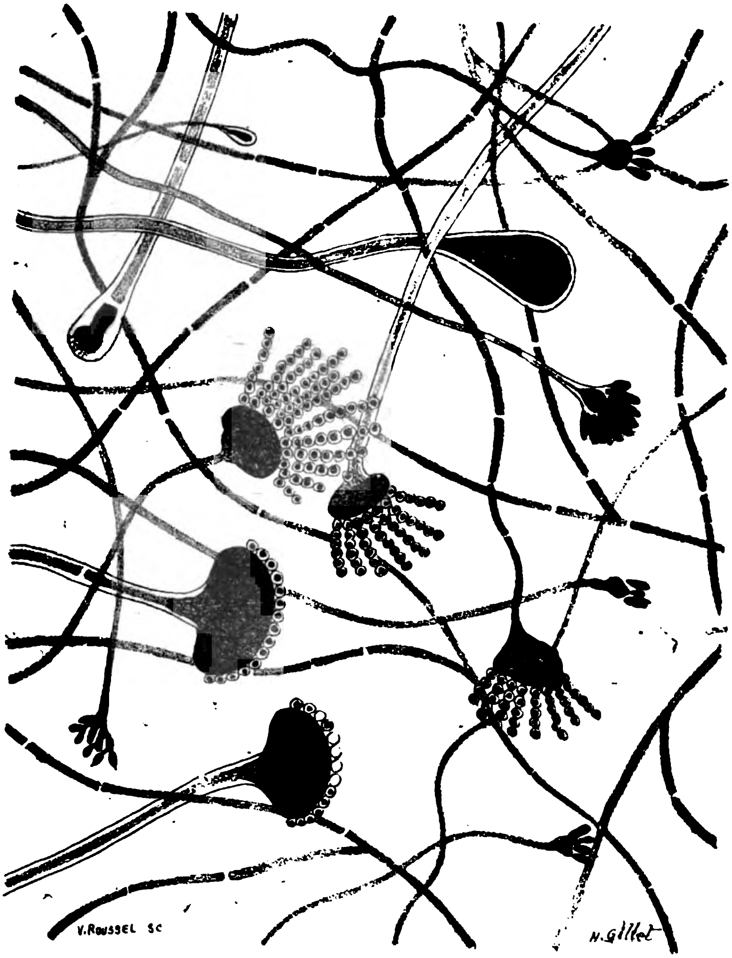

Fig. 6

Culture de 30 jours en goutte suspendue d'un caraté bleu de mines de Titiribi.

Caraté noir-violacé.

Les colonies forment un duvet blanc, frisé, et un peu long au début, qui plus tard se couvre, en allant, du centre à la périphérie, d'une poudre fine de couleur vert glauque, en restant entourée, en général, d'un collier ou anneau de duvet blanc, persistant même dans les vieilles cultures. La poudre verte tourne vite au brun violacé, qui est sa couleur définitive. Ces colonies apparaissent et se développent en peu de temps, mais ensuite s'arrêtent et restent stationnaires indéfiniment, sans envahir le reste du milieu nutritif.

Elles sont planes ou légèrement ondulées, peu saillantes, prennent rapidement, dans la gélose glycérinée, une couleur définitive lilas foncé et la gélose même est teintée en jaune-paille ou acajou.

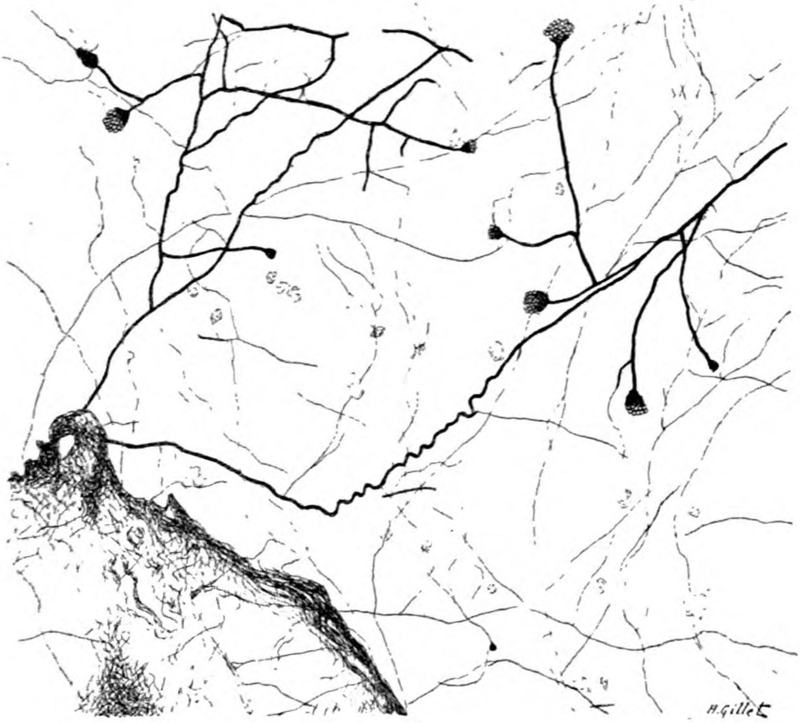

FIG. 7

Culture semi-aérobie d'une squame épidermique de caraté bleu de Titiribi (même champignon que celui de la figure n° 6).

Dans le bouillon glycériné, elles forment une bourse irrégulière, à fond de couleur lilas pâle, et d'apparence mamelonnée. Dans le liquide, on voit flotter quelques flocons filamenteux. Le bouillon est teinté en jaune-acajou.

Ce champignon est un *Aspergillus* typique et ses colonies s'associent fréquemment, chez le même individu, à celles du champignon du caraté violet-brun (5 à 10 0/0).

L'aspect morphologique ressemble un peu à celui que représente la figure n° 3.

Caraté noir d'encre de Chine.

Le champignon que l'on rencontre dans ce caraté est, dès son apparition, d'un beau noir de jais ou d'encre de Chine.

Le duvet est lisse et couché. Les colonies sont rayonnées au début. Dans les vieilles cultures, la gélose s'ondule et des filaments longs et noirs envahissent le verre, mais restent couchés et sans la moindre poudre. Les colonies ne sont pas saillantes, même sur les vieilles cultures, mais, à la fin, elles se couvrent par places d'un duvet court, droit et blanc. La gélose glycérinée se teint en noir.

Les cultures montrent deux espèces de filaments, les uns fins, plus ou moins cloisonnés, et ramifiés ; les autres sont plus gros, massués ou noueux, ce qui est dû au grand nombre de chlamydospores qu'ils renferment. De nombreux rameaux plus déliés, naissent de ces filaments massués, et portent ordinairement, à leur extrémité terminale, des conidies piriformes ou sphéroïdales volumineuses.

Ce champignon ressemble morphologiquement à certains *Microsporons*, et est un type d'Oosporée.

Dans un caraté tricophytoïde violet du département de Santander, nous avons rencontré un champignon de ce même type, mais dont les cultures sont violet-rougeâtre.

Caraté blanc.

Les colonies de ce caraté sont blanches, ou rosées au début, et formées d'un duvet long, dressé, ou plus ou moins frisé. Il se développe extrêmement vite, et envahit, en peu de jours, tout le milieu nutritif, en formant d'ordinaire des plis saillants, montagneux, couverts d'un duvet court, pulvérulent, de couleur crême, ou blanc-sale, comme la culture du *Microsporon* du chien (*Oospora canina* de Bodin).

Dans toutes les géloses, il se développe bien, mais ne secrète pas de pigment.

Dans le bouillon glycériné, il se développe mal, comme dans le liquide de Raulin. Au bout d'un temps assez long, on voit quelques petites colonies rayonnées, sur les parois du verre, et le bouillon reste limpide et stérile.

De tous les champignons rencontrés dans les caratés, c'est le plus vivace, et celui dont la vitalité est la plus persistante. Des cultures vieilles de 2 ou 3 ans, réensemencées sur gélose glycérinée, donnent en 6 à 10 heures des colonies de développement abondant et rapide.

Ce champignon se rencontre ordinairement associé au champignon noir du caraté encre de Chine, mais les colonies blanches ne se mêlent pas aux noires. En cultivant les squames des taches blanches, et celles des taches noires, d'un même malade, les noires donnent un champignon noir, et les blanches, un blanc, purs d'emblée tous deux.

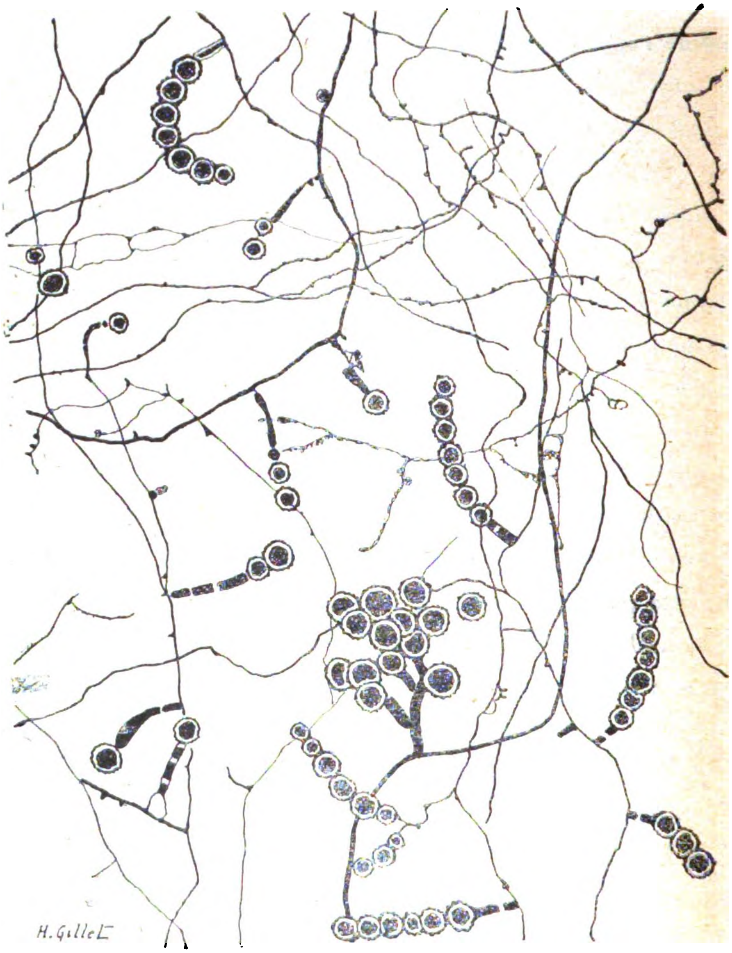

Fig. 8

Culture de 3 jours en goutte suspendue d'un caraté blanc provenant de Bello

La figure n° 8 représente une culture de 3 jours, en goutte suspendue, provenant d'un caraté blanc. Elle montre de nombreux filaments rampants, minces, plus ou moins irréguliers et dichotomiques, et quelques filaments fertiles, qui supportent de grosses hyphes droites, cloisonnées, courtes, qui soutiennent des chapelets de grosses spores échinulées et contenant un gros nucléus. Le fruit adulte complet se compose de plusieurs chapelets de spores placées irrégulièrement sur des branches secondaires, qui sortent de l'hyphe primitive, le fruit ayant l'aspect d'une grappe irrégulière.

Pour M. le professeur Van Tieghem cette espèce se rapproche du genre *Monilia*.

Caraté rouge.

Les colonies sont saillantes et ondulées, et de couleur jaune rouge, ou blanche au début ; plus tard elles se recouvrent, par places, d'un duvet verdâtre et court. Ces colonies produisent une substance, couleur d'ocre, qui teinte en partie la gélose de rouge, et qui forme un substratum ou promontoire, sur lequel repose le duvet, dans les vieilles cultures. Ce champignon présente la morphologie des *Aspergillus*.

CULTURES EN GOUTTES SUSPENDUES.

1° Prendre des tubes de culture à bords bien réguliers ou rodés ;

2° Remplir aux 2/3 d'eau filtrée ;

3° Passer un peu de vaseline sur les bords ;

4° Placer les tubes sur un support ;

5° Prendre des lamelles couvre-objet qu'on place, une à une, dans une pince de Cornet.

6° Flamber les lamelles.

7° Avec une pipette mince et recourbée déposer, au centre de chaque lamelle, une goutte de bouillon glycériné.

8° Avec l'aiguille longue M. Sabouraud, prendre une particule de poussière de la culture, et ensemencer chaque goutte délicatement.

9° Prendre les lamelles ensemencées, et les déposer, une à une, sur les tubes vaselinés, de façon que la lamelle appuie bien partout ; s'il reste des endroits sans vaseline, avec un très-mince pinceau, on passe un peu plus de vaseline, en soutenant la lamelle appuyée.

10° Placer à l'étuve entre 30°C. ou 35°C. ou même laisser parfois à la température du laboratoire.

Quand les cultures commencent à se développer on les monte successivement, à un ou plusieurs jours d'intervalle, de façon à avoir toutes les phases du développement des champignons.

Pour le montage, on suivra le procédé que nous allons indiquer.

1° Avec une aiguille-lance, enlever toute la vaseline du pourtour :

2° Prendre la lamelle avec une pince de Cornet, la passer trois fois à la flamme pour fixer ;

3° Laisser refroidir et déposer quelques gouttes d'alcool absolu, qu'on renouvelle plusieurs fois ;

4° Mettre quelques gouttes d'acide acétique cristallisable ;

5° Rincer à l'alcool absolu.

6° Verser quelques gouttes d'une solution étendue de bleu polychrome (6 gouttes dans un verre de montre) ; laisser 5 à 10 minutes ;

7° Monter sur glycérine colorée au bleu polychrome et luter avec le Masken-lack.

Par ce procédé, on a de belles préparations, qui se conservent bien, dans lesquelles les fruits portent leurs spores, ni abimées ni dispersées. C'est avec de telles préparations, que l'on peut procéder à la classification, et de plus étudier méthodiquement d'une façon commode, toutes les phases du développement.

Les préparations destinées à la photographie doivent être colorées avec une solution d'acide picrique, et montées dans la glycérine picriquée, ou au brun Bismarck. Les préparations colorées au bleu sont mauvaises, parce que cette couleur n'est pas photogène.

Culture Semi-Aërobie.

On prend une squame de caraté et on la met sur une lame stérilisée. On y dépose ensuite une ou deux gouttes de bouillon glycériné ou de liquide de Raulin. On recouvre avec une lamelle passée à la flamme du bec de gaz, et l'on lute enfin à la Masken-lack. On place alors les préparations à une température de 30°C. à 35° C. pendant quinze jours ; plusieurs mois pour quelques-unes.

Le champignon, dont le mycélium abonde dans les squames, se cultive tout autour, et produit quelques fruits petits, et incomplets. C'est par ce procédé qu'a été obtenue la préparation que représente le dessin n° 7. C'est une culture de l'*Aspergillus* qui produit le caraté bleu, et dont les fruits complets en culture aérobie, en goutte suspendue, se voient dans la fig. n° 6. Les cultures semi-aërobies montrent très bien des mycéliums déliés et stériles, et quelques filaments volumineux fertiles, qui supportent des hyphes avec fruits plus ou moins incomplets à cause de leur développement à l'abri de l'air.

Avant d'entrer dans la partie clinique de notre sujet nous allons terminer par quelques mots sur les inoculations.

INOCULATIONS

1° Prendre un lapin de couleur uniforme, le raser sur le dos;

2° Faire, au milieu du dos, des scarifications quadrillées;

3° Mettre un peu de bouillon dans un tube de culture pure du champignon à inoculer, et agiter plusieurs fois pour dégager les spores ;

4° Avec un pinceau de coton stérilisé, prendre les spores en suspension dans le bouillon, et frotter la peau scarifiée ;

5° Numéroter le lapin à l'oreille, et mettre le même numéro à la culture qui reste, et au registre des inoculations, avec la date, le nom du caraté et du champignon inoculé. Trois ou quatre jours après, les poils, qui avaient déjà commencé à repousser, tombent, complètement ou par plaques. La peau lisse au commencement, se couvre bientôt de menues squames et l'endroit scarifié présente de grosses croûtes qui tombent, une semaine après, laissant la peau glabre, complètement épilée et d'une couleur qui varie selon les espèces de caraté inoculées. Le processus ultérieur étant variable, nous allons décrire la marche du caraté noir produit chez le lapin par l'inoculation du champignon du caraté violet-brun de l'homme. C'est le plus typique et nous nous contenterons ensuite, d'indiquer pour les autres variétés les modifications évolutives importantes. Pourquoi le caraté violet-brun de l'homme, produit-il un caraté noir chez le lapin? C'est un fait que nous constatons et dont la raison nous semble être quelque modification des conditions biologiques du champignon, qui augmente son pouvoir chromogène.

CARATÉ NOIR DU LAPIN.

Quinze jours après la chute des croûtes, les poils repoussent, mais sont plus noirs que ceux qu'ils remplacent. La peau prend une teinte noir d'encre. Plusieurs îlots noirs dépilés apparaissent au pourtour, et plus tard, tous ces îlots se rejoignent pour former une grande tache festonnée, dont la teinte va en se dégradant vers la périphérie, jusqu'à se confondre avec la couleur blanche de la peau normale. Les poils repoussent partout, mais sont d'un noir foncé. Un mois après, la pointe des poils commence à devenir cendrée; en deux semaines, les poils du centre de la plaque sont de couleur normale, et la peau qui les supporte a repris sa teinte naturelle.

Si l'on rase alors le lapin, on voit une plaque centrale de peau blanche, entourée par un anneau noir d'encre.

Quelque temps après le rasage, cet anneau noir s'élargit de jour en jour, devient très desquamatif, et la peau normale blanche, rasée à la périphérie, se prend, devient noire et se dépile en même temps qu'il se produit une desquamation abondante ; quinze jours après les poils ont repoussé, et si l'on rase à nouveau, on constate l'accroissement de la plaque blanche centrale, et la progression excentrique de l'anneau noir de caraté, qui a complètement envahi la peau saine du rasage antérieur. Si l'on ne rase pas, le caraté guérit spontanément du centre à la périphérie, et toute coloration anormale disparaît.

Il nous a semblé que les lapins complètement noirs, mais qui, après le rasage, ont une peau uniformément blanche sont les meilleurs pour les inoculations du caraté noir, obtenu chez les lapins avec l'*Aspergillus* de culture brun clair, du caraté violet-brun. Ce caraté apparaît chez eux, et se développe en moins de deux mois.

Le caraté violet, produit par l'*Aspergillus* à cultures saillantes, de couleur vert glauque persistant dans tous les milieux, est d'un développement lent, de même que le caraté bleu, dû à un *Aspergillus* à cultures saillantes, acuminées, et qui se couvrent de replis lisses, jaunâtres, favoïdes.

Les champignons du caraté noir encre de Chine, et du caraté blanc ne reproduisent pas la maladie, mais laissent sur les mouchetures d'inoculation, une plaque lisse, complètement dépilée, qui dure un ou deux mois, sans s'accroître, et qui, finalement se recouvre de poils, sans aucun changement de coloration.

Les inoculations à l'homme sont positives, d'après mon ancien interne, le D^r Lazaro Uribe, qui a inoculé les *Aspergillus* des caratés violets, à plusieurs mulâtres, qui, spontanément, s'offrirent pour cet essai. Mais, malheureusement, comme les taches livides ou violettes qui apparurent, durent être détruites promptement, les observations restent incomplètes et l'on ne peut en tirer une conclusion ferme et définitive.

Nous allons donner l'observation de la plus typique de ces inoculations.

Un mulâtre, Andrès Albarez, qui avait été inoculé au bras gauche par Uribe, et qui n'avait pas voulu laisser toucher la petite tache violette, prurigineuse et desquamative qui était apparue un mois après l'inoculation, vient me consulter, huit mois après, et me montrer la tache de caraté artificiel, qui présente l'aspect suivant : tache livide, à contour circiné, non prurigineuse, et légèrement furfuracée, d'un diamètre de cinq centimètres, la surface inoculée, ayant eu un centimètre.

Cet individu, agriculteur de profession, n'a jamais présenté et n'a pas encore, actuellement, d'autre tache de caraté, que celle inoculée, que je lui ai recommandé, expressément, de traiter par la teinture d'iode.

CONTAGION ET MOYENS DE PROPAGATION

Les caratés ne sont pas contagieux, par contact direct, ni par l'usage du linge de corps d'un malade, sauf peut-être, exceptionnellement. Un « caratejo » n'est pas dangereux pour son entourage. On voit souvent en effet, une famille de dix ou douze personnes, dont le père et la mère ont le caraté, et dont les enfants sont indemnes. On n'a jamais vu une mère « carateja » passer la maladie à son nourrisson. Les cas de caraté communiqués ou acquis dans les relations sexuelles avec des individus malades, sont douteux ou au moins très rares.

Le vulgaire croit qu'en faisant avaler des squames des caratés, avec du chocolat, par exemple, la contagion est sûre. De nombreux métis ou mulâtres racontent que leur caraté leur a été passé dans du chocolat, par une femme jalouse, comme vengeance. Mais est-il besoin de le dire, il n'existe pas d'observation authentique de contamination par ce moyen.

Etant donnée l'existence saprophytique des moisissures des caratés dans des milieux et substances diverses, il n'y a pas en général besoin d'une contagion humaine. Ce qu'il faut, avant tout, pour contracter le caraté, c'est un terrain approprié à la germination des spores, et un climat chaud et humide, où les eaux, les graines, les broussailles, les insectes, et en particulier les moustiques et les punaises se chargeront de fournir ou de semer les graines.

Nous avons obtenu des cultures pures d'emblée, avec les eaux qui sortent de plusieurs mines aurifères. Mais le champignon n'existe que dans les endroits où l'eau n'a pas de courant, et sur les cailloux et la terre qui forment le bord des flaques stagnantes.

Parmi les agents les plus actifs d'inoculations sont les moustiques, moucherons, « mosquitos », « gegen » dans la langue du pays, appartenant au *G. Simulium*, (ordre des Diptères), qui assaillent l'homme le jour ; les *Culex* « zancudos » et les punaises du *G. Acanthia* « chinches » qui l'attaquent la nuit, et dont les organes de succion perforent l'épiderme et y introduisent les spores. Les larves et les nymphes des culicidés et des simuliés vivant, d'après M. le professeur Raphaël Blanchard (*Zoologie médicale*, T. II 1890) dans les eaux stagnantes, on voit quelle importance étiologique prend le voisinage immédiat des marécages, cours d'eau et forêts.

La piqûre des insectes du genre *Culex*, quoique plus douloureuse, et malgré la multitude innombrable des représentants de ces espèces sur les grandes rivières, n'est pas admise par le peuple comme cause du caraté, et n'est pas prouvée scientifiquement. Celle au contraire des *Simuliums*, moins grave au point de vue douleur, expose bien davantage à la transmission des caratés. Nous avons, en effet, obtenu par la culture des moustiques du genre *Simulium* des moisissures du caraté violet, du caraté noir-violacé et une oosporée à cultures favoïdes de couleur jaune pâle, en même temps que plusieurs bactéries et microcoques. Des cultures de « zancudos » culicidés) provenant des grandes rivières : Magdalena

Cauca, n'ont donné qu'une fois des colonies sur vingt tubes ensemencés.

Les punaises des grands centres à caratés : Antioquia, Sopetran, ont, presque toujours, donné les champignons des caratés noir-violacé, violet, et une oosporée semblable à celle que donnent les *Simuliums* et qui se trouve dans les caratés jaunes ou tigrés de même provenance. Ces punaises, du genre *Acanthia*, connues sous le nom de « chinche garrapata » et « chinche cucaracha » sont plus grandes et plus voraces que les espèces ordinaires.

Dans les graines de certaines céréales, et sur beaucoup de plantes, on trouve un champignon très semblable à certains caratés violets.

Sur un bon terrain (chez les gens de couleur) la cause la plus efficace de l'apparition des caratés est l'inoculation sur les parties découvertes, par piqûre des simuliens qui véhiculent de nombreuses spores des divers caratés, ou par celles de certaines punaises. Ces faits sont connus du peuple, et l'on possède des observations de caratés survenus autour de leurs piqûres.

Un autre grand moyen de propagation est l'habitude, chez les travailleurs des mines surtout, de se laver les pieds, les mains et la figure dans des ruisseaux sulfatés appelés dans le peuple « aguas con caparrosa » eaux à couperose.

Ces eaux contiennent des cultures presque pures des champignons du caraté violet cendré, qui, sur une peau irritée, crevassée, macérée par l'usage courant de ce liquide corrosif, vont germer et se développer dans des conditions générales de terrain favorable.

ANATOMIE PATHOLOGIQUE.

Dans les caratés violets, rouges et noirs-violacés, au début, le champignon est épidermique. Dans certains points, et dans les caratés vieux, le champignon pénètre une partie du corps muqueux de Malpighi. D'une façon générale, ces champignons produisent une irritation du corps muqueux, dont les cellules d'abord se multiplient, pour diminuer ensuite. Il se produit une disparition complète des cellules pigmentaires de la peau, dans les taches achromiques périarticulaires.

L'examen comparatif de coupes au microtome de taches violettes et de taches acromiques articulaires, attire l'attention sur l'amincissement et l'atrophie du corps muqueux dans l'achromie, et sur son épaississement un peu supérieur à la normale dans les taches violettes.

En général les cellules cornées épidermiques de la tache achromique forment une couche dont l'épaisseur est identique à celle de la peau normale du même individu, tandis que la couche épidermique des taches violettes est plus considérable. Dans les caratés blancs et rouges, le champignon est toujours épidermique mais, dans certains points, (surfaces palmaire et plantaire) il pénètre dans le corps muqueux.

Autour des poils follets, se forme un anneau fibreux, qui expulse le poil, sans que le champignon y pénètre. La racine du poil est effilée en pointe d'aiguille. A la place du poil, reste une élévation kératosique, aussi dure qu'un grain de sable. Les élévations calleuses des mains dans les caratés rouges, sont composées d'une grande quantité de spores emprisonnées dans un tourbillon de fibres kératosiques concentriques.

Les ongles, comme les cheveux, ne sont pas envahis par les champignons des caratés.

SYMPTOMATOLOGIE

Le temps d'incubation des caratés est très difficile à fixer, à cause de l'incertitude des renseignements fournis par les malades, gens en général peu soucieux de leur personne et surtout parce que les caratés ne présentent pas de coloration caractéristique au début, mais seulement quelques mois, un an, ou même deux, après l'époque de l'invasion.

L'apparition est apyrétique toujours, lente, insensible, sans le moindre trouble de la santé générale, chronique d'emblée et passant inaperçue. Les changements de coloration sur les endroits où apparaîtra l'hyperchromie caractéristique sont parfois accompagnés d'un léger prurit. Les premières taches sont en nombre variable, petites, arrondies, d'une couleur pâle, livide ou jaune claire, dans la pluralité des cas, ou bien rougeâtres, ou grisâtres. Elles sont très apparentes, et marquées chez les gens de couleur. Le peuple les appelle « paños de carate » il y a une desquamation furfuracée légère, les lieux d'élection sont d'abord la figure et la nuque.

A la figure les premières taches dischromiques se voient sur les pommettes, le dos et la pointe du nez, la partie inférieure du front, la partie antérieure et supérieure des oreilles. On les observe ensuite, et par ordre de fréquence, sur les avant-bras, les poignets, les jambes, les cou-de-pieds, et la partie supérieure de la poitrine. A cette même période, d'après Uribe Angel, la démangeaison palmo-plantaire est très marquée.

Les premières plaques grandissent et tout autour, on en voit apparaître d'autres, plus petites, qui en se joignant aux centrales forment des taches orbiculaires ou festonnées de deux à cinq centimètres de diamètre. Le contour, chez les gens de couleur foncée, est net. Chez les anémiques de race blanche, elles vont en s'atténuant et finissent par se confondre avec la couleur normale de la peau voisine. Leur surface est au niveau de la peau environnante. Quelques grandes taches commencent à se foncer au centre, qui devient violacé, rougeâtre, bleuâtre ou brun cendré. Celles qui sont très exposées au soleil se foncent de plus en plus, et au bout de 2 ou 3 ans ont acquis la teinte caractéristique : violet, rouge, bleu ou noir-violacé. Sur un même individu et, maintes fois chez les femmes, on trouve des taches à diverses périodes de développement, les unes pâles comme des taches de lait ; les autres orbiculaires, plus grandes et formées de trois anneaux concentriques, comme une cocarde ; l'intérieur est violet, bleu ou brun, furfuracé ; la zone moyenne est presque lisse, gris acier et l'anneau externe est complètement lisse, pâle, livide et en général plus large à lui seul que le reste de la plaque. Quelques autres taches volantes, plus ou moins disséminées, à contours festonnés présentent distinctement la couleur caractéristique du caraté.

Les taches hyperchromiques ne gardent aucune symétrie, et, d'abord limitées aux parties ordinairement découvertes et exposées au soleil, elles peuvent se généraliser à toute la surface cutanée et aux *muqueuses.*

La desquamation, peu marquée au début, augmente surtout au bout d'une dizaine d'années et devient permanente, l'épiderme s'exfolie en squames blanc-sale et sèches assez menues, comme le son du maïs, « afrecho » du vulgaire. Les taches peuvent rester isolées par des espaces de peau de couleur normale. Le plus généralement, plusieurs d'entre elles se confondent et forment de larges plaques géantes, festonnées, à contours géographiques qui occupent un membre tout entier, la poitrine ou le dos. Dans cette période de la maladie, le prurit est très marqué, surtout quand l'individu va transpirer, ou le soir, dans les lieux chauds quand il se couche, peut-être pour la même raison. Il y a une certaine hyperkératinisation, dans tous les endroits touchés par le parasite. Les surfaces palmo-plantaires sont considérablement épaissies, dures, comme cartonnées. Les plis naturels s'accentuent d'abord, puis, pour ainsi dire, se fixent et finalement les mouvements professionnels répétés finissent par les ulcérer profondément. Ces fissures sont extrêmement douloureuses et parfois saignantes, mais nullement fétides. En même temps, surtout dans l'espèce rouge, la plante des pieds et la paume des mains présentent des clous calleux très durs, en général gros comme une tête épingle, ou une lentille, très douloureux à la pression ou même au simple contact. Par époques assez régulières, l'irritation est telle, non seulement pour les mains et les pieds, mais pour toutes les taches, que le malade ne peut ni marcher ni se servir de ses mains, qui sont le siège d'une cuisson douloureuse. Simultanément, son caractère devient sombre et la moindre contrariété le met en colère. Il est à remarquer que la surface des taches est plus sèche. Ce fait d'aggravation et d'agacement périodique est constant chez tous les carateux et peut durer environ une quinzaine de jours. Il coïncide probablement avec la fructification et le renouvellement partiel du champignon parasitaire. Les mains perdent leur délicatesse de toucher et deviennent rudes comme des limes.

Les bras et les jambes paraissent parfois couverts par une couche de silicate ou de collodion qui se craquèle partout par les mouvements; mais cette forme fissuraire pour le corps, n'est en sorte que transitoire, tandis qu'elle est permanente pour la paume des mains et la plante des pieds. Chez les vieux carateux, la peau malade est épaissie, lichénoïde, squameuse, pleine d'élevures comme des têtes d'épingle, et ressemble à la chair de poule ou mieux à la kératose pilaire. En effet, chez ces mêmes individus, on a vu tomber tous les poils follets, qui ont été remplacés par ces mêmes élevures kératosiques, cornées. Il se produit donc, à une période avancée de la maladie, une chute complète des poils follets des plaques de caraté.

Le poil sans être pris lui-même, comme dans les teignes, est expulsé par une sorte de folliculite fibroïde, et sa racine est effilée en aiguille. Les poils cessent de s'accroître, périclitent et tombent par le grattage, mais leur coloration ne change pas. Ils ne deviennent blancs que chez les gens âgés, dont tout le système pileux blanchit. Si l'on observe un homme de 30 à 40 ans, ses poils follets tombent, expulsés qu'ils sont, par l'hyperkératinisation générale, mais ils gardent en tombant leur couleur naturelle primitive.

Les « caratejos » n'ont pas une odeur *sui generis*, sauf l'odeur particulière des nègres et de la sueur des gens de couleur, et celle due à la malpropreté personnelle, circonstances qui se trouvent réunies chez beaucoup d'entre eux. Les blancs, de même que les métis et les nègres carateux, qui se maintiennent dans un état de propreté suffisant, n'ont pas une odeur différente de celle d'un individu sain de même race.

Comme l'avait déjà remarqué Uribe Angel, la peau des lèvres, de la lèvre inférieure surtout, se sèche, se tiraille et se crevasse, produisant une sensation de cuisson permanente, et occasionnellement, de la gêne et de la douleur dans les mouvements. Cela se voit surtout dans les vieux caratés rouges et principalement violets-rougeâtres des collines froides.

Dans son langage pittoresque M. Uribe Angel s'exprime ainsi : « Des croûtes épaisses se détachent avec abon-
« dance, et le « caratejo », en même temps qu'il est un
« objet d'antipathie, pour les autres, se déplaît dans sa
« propre compagnie. Les lèvres se fendillent ; la préhen-
« sion des aliments, le rire, le baillement, l'éternuement

« et même la parole cessent d'être l'expression du plai-
« sir pour se changer en douleur et en peine. »

Le champignon du caraté n'affecte jamais les cheveux, et tous les carateux ont généralement une chevelure luxuriante et touffue, qui contraste avec le manque très fréquent de poils sur la figure. En effet, si le caraté est apparu à la face dans la jeunesse, avant que la barbe ait fait son apparition, le duvet qui la précède tombe par le même mécanisme que les poils follets du corps, et il n'y poussera plus de poils.

L'individu restera imberbe toute sa vie. Mais, comme les taches carateuses n'affectent pas toute la figure, les endroits sains présentent quelques poils, surtout aux moustaches. Un autre fait d'observation est que, si le sujet acquiert le caraté à l'âge adulte, alors qu'il a toute sa barbe; il n'aura pas le caraté à la figure s'il porte toute sa barbe sans jamais la raser. S'il se rase fréquemment, un jour ou l'autre le caraté envahira la face, et tous les poils de la barbe tomberont un à un, jusqu'au dernier.

Les taches de caraté peuvent affecter toutes les couleurs de l'arc-en-ciel. Ces taches peuvent, sur un même individu, être toutes d'une même couleur, avec des différences d'intensité, ou au contraire, de couleurs distinctes, et ces personnes ainsi peinturlurées des diverses couleurs ont un aspect de carnaval des plus grotesques. Certains individus à peau bronzée, présentent des reflets métalliques comme ceux du cuivre ou de l'acier chauffés au feu.

Les diverses espèces de caratés, par rapport à leur coloration, sont dans l'ordre de fréquence :

1° Le caraté violet : couleur violette, avec plusieurs nuances : rougeâtre, bleuâtre, cendré, brun.

2° Noir-violacé et noir-cendré.

3° Rouge.

4° Bleue avec une variété, bleu-verdâtre.

5° Jaune.

6° Noir encre de Chine.

7° Blanc.

Le carate polychrome ne forme pas une espèce, mais un résumé de tous les autres en quelque sorte.

Cette diversité de couleurs paraît en relation avec le champignon qui produit l'espèce de caraté, et même la variété. De plus, quelques-uns de ces champignons sont chromogènes, et secrètent un pigment, qui doit entrer pour beaucoup dans la coloration anormale de la peau. En effet, la couleur du champignon qui se rencontre dans les squames de chaque espèce ou variété de caraté, garde une étroite relation avec la teinte du caraté. Ainsi, par exemple, la culture de l'*Aspergillus* qui produit le caraté noir-violacé est de couleur brun-violacé; et l'*Aspergillus* du caraté bleu, est bleu. Celle de l'oospore du caraté noir-encre de Chine, est couleur de charbon.

Les taches blanches d'achromie péri-articulaire sont communes à tous les caratés, sauf peut-être au caraté rouge, qui, en général, n'est acccompagné d'achromie en aucune partie du corps.

L'achromie des régions articulaires apparaît dans les points plus exposés au frottement, et où la peau ne peut fuir, supportée qu'elle est par un os saillant. La macération des parties souvent plongées dans l'eau, a une influence sur l'apparition hâtive de ces taches. Les articulations affectées sont par ordre de fréquence : doigts, métacarpe, radius, cubitus, malléoles, métatarse, coude, genou, acromion, trochanters, et parfois colonne vertébrale lombaire. Ces taches blanches sont le plus souvent symétriques, et les endroits touchés par cette espèce l'achromie, ne sont jamais repris par le caraté hyperchromique. Elles sont lisses, non desquamatives. La peau n'est en général pas atrophiée, excepté chez les vieux, où elle est amincie et ridée, et ces endroits ne sont pas le siège de démangeaisons ou de fissures. Enfin, comme les squames de cette achromie, tout en ayant de longs filaments mycéliens, ne donnent, dans des milieux variés, aucune culture, nous considérons comme très probable que ce sont de simples lésions régressives, de n'importe quelle espèce de caraté, ou bien qu'elles sont dues à un état pléomorphique du champignon. Il n'y aurait dans cet état que des filaments de mycélium radiculaire stérile sans aucune trace de spores, ce qui concorderait avec le résultat négatif des cultures. En attendant que de nouvelles recherches prouvent le contraire, nous considérons les taches blanches de régions articulaires accompagnant les divers caratés, non comme une espèce distincte, mais comme un simple symptôme, assez constant, des caratés.

Sur les taches violettes des coudes, ou des malléoles, on peut suivre très bien l'apparition et la marche des plaques achromiques régressives. On voit en effet sur le côté gauche, par exemple, une grande tache de caraté violet, qui occupe tout le coude, mais au centre, il y a une tache d'un demi à un centimètre de diamètre, d'un blanc rosé, lisse, entourée d'une zone plus pâle, et qui va en se fondant, se réunir au violet qui l'entoure. Au coude droit, plus exposé aux frottements, si le sujet n'est pas gaucher, on voit aussi une couronne violette, et au centre, une tache blanche, large de 3 ou 4 cent. entourée par un disque violet foncé, qui, deux ou quatre ans plus tard aura disparu complètement, ne laissant qu'une tache achromique de 5 à 6 centimètres. Comme règle générale, on peut dire que l'achromie régressive apparaît la première, là même où les conditions professionnelles avaient fait apparaître d'abord les taches hyperchromiques de chaque caraté. Les frottements qui avaient prédisposé à l'implantation du parasite, finissent par lui faire abandonner les endroits trop exposés aux pressions continuelles, ou l'amènent à prendre une forme pléomorphique de résistance, et dans ce cas, si l'on arrive un jour à cultiver les filaments qui se trouvent dans les squames achromiques, ces cultures devront montrer le même champignon causal que l'on trouve dans le caraté qui accompagne l'achromie.

En fait, les variétés pléomorphiques des champignons des caratés, ont une couleur blanche ou jaune pâle, comme celle des favus, et sont en plus, difficiles à cultiver et d'un accroissement extrêmement lent.

La leucodermie, qui apparaît primitivement sur d'autres parties que les régions articulaires ; qui forme des plaques blanches géantes, sur la poitrine, l'abdomen, les bras, les cuisses, les jambes, etc.; se généralise en 5, 10, ou 20 ans, et arrive à blanchir toute la surface de la peau et à faire un blanc, d'un mulâtre, ou d'un métis, est de toute autre nature que l'achromie péri-articulaire. Cette leucodermie est seule ou associée assez souvent au caraté noir encre de Chine, et paraît due, comme lui, à une oosporée. Il y aurait alors une leucodermie parasitaire, ou vrai caraté blanc, mais, qui, comme symptomatologie et mycologie, ainsi du reste que le caraté noir encre de Chine, et le jaune, différerait de ceux que nous venons de décrire.

Ces trois derniers caratés : blanc, noir encre de Chine et jaune sont des anomalies pigmentaires, à proprement parler, plutôt que des maladies, et plus importantes au point de vue de l'esthétique pure, qu'au point de vue nosologique. En effet l'état général n'est pas atteint le moins du monde. Pas de desquamation, pas de gerçures ni d'hyperkératinisation, pas de démangeaisons. Le changement de couleur paraît constituer, à lui seul, toute la maladie. En tous cas de nouvelles recherches sont indispensables dans ce sens.

Pour terminer ce chapitre, nous ferons remarquer que les caratés peuvent prendre des formes atypiques, et ressembler absolument à des trichophyties de la peau que l'on dit glabre : caratés trichophytoïdes rouge, ou violet ; aux favus scutellaires de la peau : caraté favoïde ; prendre l'aspect d'un impétigo gyroïde concentrique : caraté impétigineux ; d'un lupus érythémateux desquamatif : caraté rouge lupoïde ; ou bien, ce qu est très fréquent, prendre les allures d'un lichen : caraté lichénoïde.

ESPÈCES ET VARIÉTÉS DES CARATÉS.

Espèce violette.

Des sujets affectés de cette forme peuvent présenter des taches hyperchromiques des couleurs suivantes : violet clair pur, violet-cendré, violet-rougeâtre, violet-bleuâtre et violet-brun.

C'est une maladie rurale, des champs, et des mines surtout. Elle n'est, ni héréditaire, ni familiale, et se rencontre même chez des enfants de trois et cinq ans. Elle commence presque toujours sur la figure par des taches livides ou fumées. Chez le même individu, on voit, côte à côte, des taches dischromiques d'une couleur livide, des taches violacées et des taches de teinte fumée. La pointe du nez présente très souvent une tache violette isolée. En général, l'achromie péri-articulaire est précoce. Aux poignets, elle prend l'aspect d'un anneau et forme comme un bracelet blanc incomplet, resté ouvert sur le dos de l'avant-bras et empiétant sur la paume de la main. Cette achromie palmaire est marquée, surtout chez les négresses cuisinières, ou laveuses des sables aurifères. Aux coudes, il est fréquent de voir trois points blancs d'achromie précoce, sur la peau qui recouvre l'olécrane, l'épitrochlée et l'épicondyle et, tout autour, une couronne violet foncé ou bleuâtre. Chez les personnes qui plongent souvent leurs mains dans l'eau, (meuniers des mines, bateliers, blanchisseuses), l'achromie commence par de petits points blanchâtres sur la peau des articulations métacarpo-phalangiennes. Le dos des mains présente un aspect pseudo-vitiligineux moucheté, dû à la persistance d'îlots de coloration normale, dont l'hyperchromie ethnographique tranche nettement sur l'achromatose articulaire.

Par époques, pendant quinze jours ou un mois, les parties affectées de caraté (surtout les surfaces palmo-plantaires) deviennent plus sèches, crevassées et cuisantes. Puis la peau reprend une souplesse relative ; la cuisson et les crevasses disparaissent. Parfois, mais rarement, il apparaît aux jambes une ou deux plaques localisées de caraté violet très prurigineux, qui se crevassent et par le grattage arrivent à s'ulcérer. Ces ulcérations deviennent chroniques et sont très rebelles au traitement.

Dans la variété violet-cendré, l'achromie périarticulaire est plus tardive, et manque parfois. La desquamation est ici très abondante, et le prurit intense oblige les malades à se gratter presque constamment. Les poils follets des taches tombent par le grattage, et laissent de petites élevures kératosiques. Cette forme est presque spéciale aux environs des grands fleuves, à température élevée (30° à 35°), comme à Zaragoza, Cruces de Caceres, Remedios, villages plus ou moins miniers, aux approches de la rivière du Cauca ou du Magdalena.

Les formes violettes pures sont moins desquamantes, ont plus de tendance à fendiller la peau, et produisent une cuisson très désagréable. En même temps le siège des taches est plus vascularisé, et saigne abondamment à la moindre égratignure. Les surfaces palmo-plantaires s'hyperkératinisent et se fissurent dans tous les plis formés par les mouvements habituels.

Le caraté violet rougeâtre est aussi peu desquamatif, mais très fissuraire, irritant et s'attaquant presque toujours aux surfaces palmo-plantaires et aux lèvres, qui sont continuellement sèches et sillonnées de crevasses brûlantes. Ce caraté est particulier aux métis habitant les collines froides (10° et 18°) très exposées aux vents.

Les muqueuses buccale, balano-préputiale et vaginale, sont souvent prises chez les vieux carateux qui portent la variété violet-brun, et même quand toutes les taches de la peau sont devenues achromiques, celles des muqueuses restent indéfiniment violet-brun.

Chez les enfants atteints de caraté violet, on ne voit d'achromie péri-articulaire, qui ne se rencontre ordinairement que chez les adultes de vie active ou chez les vieux carateux.

Le caraté violet peut se trouver, sur un même sujet, à côté du blanc vrai, du noir-violacé, du rouge et du bleu. Ces taches occupent différentes régions, et apparaissent simultanément, ou d'une façon successive. Elles sont autonomes, et chacune garde indéfiniment sa coloration, sans que les unes soient la suite des autres. C'est une vraie forme polychrome, ou multicolore, très fréquente, et dans laquelle chaque tache de couleur différente est produite par une espèce distincte d'*Aspergillus*.

Les squames épidermiques d'un même individu, prises sur plusieurs de ces taches, donnent à la culture, deux, parfois même, rarement, trois *Aspergillus* différents.

La guérison spontanée peut survenir chez les vieux carateux, surtout à la suite d'une maladie fébrile, et de longue durée (variole). Cette terminaison est rare et la durée est habituellement indéfinie. Les gens, qui en sont atteints vaquent à leurs occupations habituelles, et sont employés, sans crainte de contagion, dans tous les métiers. Il est à remarquer qu'une grande quantité de mulâtresses occupées dans les familles blanches comme bonnes d'enfants, et qui couchent même avec eux, ont le caraté, et on n'a jamais vu un cas de contagion d'un enfant ou d'une autre personne de la maison. De même, dans l'armée, il y a une certaine quantité de soldats porteurs de caratés, et qui ne contagionnent pas leurs camarades.

Les carateux qui ont de l'hyperkératinisation et des fissures profondes et multiples palmo-plantaires, souffrent beaucoup, sont même forcés de suspendre tout travail manuel et viennent alors seulement consulter le médecin. On voit souvent des muletiers avec des rhagades profondes de la plante des pieds, qui pour éviter les cailloux du chemin, se font le soir, dans les hôtelleries où ils se reposent avec leurs mulets, des sutures au fil d'agave.

Quand il n'y a pas encore de l'achromie péri-articulaire, le caraté violet et toutes ses variétés, peuvent être guéris, sans laisser de traces, mais, si les régions articulaires sont déjà blanchies par la maladie, elles resteront telles quelles jusqu'au dernier jour du patient. Si après la guérison, le sujet reste soumis aux mêmes influences qui avaient produit le caraté, la récidive est certaine, avec la même forme, ou plus souvent sous une forme trichophytoïde d'abord, qui, plus tard, reprendra son aspect de caraté diffus, plus ou moins généralisé au bout de quelques années.

Espèce noir-violacé.

Ce caraté se montre primitivement sur les avant-bras, par des taches grisâtres qui prennent ensuite une teinte brune à reflets violacés et dont la couleur définitive est noir d'encre. Le développement est très lent ; les taches ne se généralisent pas, comme le violet et restent cantonnées sur les avant-bras, les jambes ou la figure, sans aucune tendance à l'extension. L'achromie péri-articulaire est très tardive, mais quand elle apparaît, elle fait en peu de temps des progrès rapides et forme des taches géantes, qui, par propagation, envahissent les membres et même le tronc.

Les malades présentent fréquemment des taches achromiques, sur la peau du dos, au niveau des apophyses épineuses. Ces placards blancs sont ordinairement entourés d'une couronne violette, plus ou moins foncée, et plus ou moins desquamative. On voit parfois des individus, porteurs d'énormes plaques achromiques lisses, sur presque toutes les articulations et paraissant ne pas avoir de taches de caraté noir-violacé ; mais, en les examinant attentivement, à la périphérie de ces taches leucodermiques, on finit par trouver quelques petites taches noir violacé, desquamatives et prurigineuses. Ordinairement, ces mêmes individus sont porteurs de taches noir violacé sur les muqueuses : palatine, linguale, gingivale, labiale et balano-préputiale, qui montrent que c'est bien d'un caraté noir achromique et non d'un caraté blanc primitif ou leucodermie parasitaire, qu'il s'agit. Il est très fréquent de voir, trente ans après le début des premières taches de caraté, apparaître une tache tardive, sur le dos du nez et les joues, dessinant grossièrement un énorme papillon noir dont les ailes seraient déployées.

La chevelure n'est pas touchée par le parasite ; mais les poils follets des taches carateuses périclitent et finissent par tomber. Ce caraté n'est pas hyperkératinisant, et l'épiderme est plutôt aminci et peu desquamatif. Le prurit est modéré. Les surfaces palmo-plantaires sont parfois fissurées, saignantes, et douloureuses par époques. En vieillissant, les taches noires deviennent d'un gris cendré ou plombé. La guérison spontanée est rare, la métamorphose en leucodermie généralisée est plus fréquente. C'est une maladie des nègres et des mulâtres habitant les mines et les rivières entourées de forêts considérables, dont la température est élevée et l'air humide.

Espèce rouge.

C'est une maladie urbaine et qui affecte surtout la race blanche, dans les villes à climat tempéré ou froid. Elle paraît familiale, mais non héréditaire, ne s'attaque qu'aux adultes, dure indéfiniment et ne guérit pas spontanément. Il y a des vieux blancs qu'on croirait volontiers très sanguins, et qui sont simplement « carminés » par le caraté.

Il commence par des taches pâles qui deviennent vite rouges, et se généralisent d'une façon diffuse, sans contours bien limités, et sans desquamation marquée. D'autres fois, elles se localisent ; les taches sont très desquamatives, en relief, et à contours festonnés, qui tranchent nettement sur la peau normale. Dans les formes localisées, les poils follets tombent de bonne heure. La chevelure et la barbe ne sont jamais touchées.

Ce caraté produit une sensation de sécheresse et de cuisson ou de brûlure de la peau, plutôt que de prurit. Les surfaces palmo-plantaires sont envahies de bonne heure. Un semis de grains kératosiques apparaît sur les paumes des mains ; les plantes des pieds se dessèchent, s'épaississent et se fissurent, quand le malade marche nu-pieds. Par époques périodiques, les malades ressentent une grande sécheresse et une sensation de brûlure, partout où le caraté a touché, mais surtout aux surfaces palmo-plantaires, qui deviennent très sensibles, et dont les crevasses saignent facilement.

Il est à noter que, si le sujet ne se livre pas à un travail matériel, les rhagades sont rares.

Dans les formes diffuses, la desquamation est modérée. Il se produit parfois de l'ectropion de la paupière inférieure; les conjonctives deviennent rouges et congestionnées, d'une façon chronique. Les lèvres se dessèchent et se fendillent plus ou moins.

Dans la forme pure du caraté rouge, l'achromie périarticulaire ne survient pas. Le rouge peut évoluer à côté des taches violettes, chez le même sujet, et alors seulement, on peut voir de l'achromie articulaire. La santé générale est excellente, mais les malades sont très irascibles et n'aiment pas à entendre parler de leur maladie. Cette méchante humeur est due probablement à l'exaspération nerveuse produite par la sensation de sécheresse et de cuisson de la peau, ainsi qu'à un réflexe particulier des filets nerveux terminaux comprimés par la congestion habituelle et irrités par la végétation cryptogamique.

Espèce bleue.

Elle commence par des taches rougeâtres, diffuses, qui peu à peu se colorent en bleu plus ou moins foncé. Son lieu d'élection est la figure, et le dos des mains. Ces taches se confondent avec la peau par une dégradation insensible de la teinte. Elles sont lisses sans relief ni desquamation. Les muqueuses ne paraissent pas être atteintes. Il n'y a ni sécheresse ni crevasses. Les surfaces palmo-plantaires sont peu touchées, et le prurit est minime, ou n'existe pas.

Ce caraté peut se généraliser au bout de vingt ou trente ans, mais il est peu gênant. Les poils follets tombent très souvent ; la chevelure n'est jamais touchée, et cette espèce, comme toutes les autres, est exclusivement épidermique, et jamais pilaire. Cette forme se voit chez les péons des champs labourés ou des mines ; chez certains mineurs, on voit en plus des taches verdâtres à reflets pyriteux, ces individus ont le visage de la couleur de la peau de certains lézards des mêmes contrées L'achromie articulaire est tardive et très discrète. Les petites articulations des mains et des pieds sont à peine mouchetées de blanc. Le caraté bleu se rencontre chez les ouvriers de race blanche ou métis.

Espèce jaune tigrée

Elle est fréquente chez les métis habitant près de certaines rivières sur les bords desquelles se cultivent le cacao et le tabac. Elle commence sur la poitrine ou sur les bras par des taches jaune clair, ou plus ou moins safranées, se généralise à tout le tégument externe, et est accompagnée de petites taches achromiques qui, étant séparées par des îlots de peau saine, donnent à la peau du malade l'aspect de la robe du tigre.

Les taches jaunes sont plus ou moins larges, parfois lentigineuses aux mains et au visage. La peau des petites articulations des pieds et des mains se pointille de bonne heure de blanc. Il n'y a pas de prurit, pas de desquamation ni de lésions palmo-plantaires, à part l'achromie qui peut envahir la paume des mains. D'autres fois, les taches achromiques du tronc deviennent énormes et, séparées qu'elles sont par des bandes hyperchromiques jaunes, ou par la peau normale, elles donnent au tégument du sujet, l'aspect du jade, ou du ventre de certaines couleuvres.

Chez les vieux carateux, il survient une desquamation furfuracée, accompagnée de prurit léger, mais la peau reste souple. Ce caraté est difficile à guérir et ne disparaît pas spontanément.

Espèce noir-encre de Chine.

Elle se trouve presque exclusivement sur les nègres pur-sang, descendants des anciens esclaves importés d'Afrique par les conquérants, à l'époque coloniale.

Ce sont des taches noires, si foncées qu'elles tranchent nettement sur une peau d'ébène. Elles apparaissent entre 18 et 30 ans : au front, au menton, aux avant-bras et aux jambes. Ces taches ont ordinairement de 0, 05 à 0, 20 centimètres; se généralisent exceptionnellement, et restent le plus souvent stationnaires, pendant de longues années. Elles sont lisses, non desquamatives ni prurigineuses. A leur niveau, la peau est très vascularisée et l'épiderme très adhérent. Pas de crevasses, ni la moindre gêne palmo-plantaire en général. La chevelure reste intacte, mais les poils follets tombent ordinairement. Ce caraté reste réduit à trois ou quatre taches noires, pendant de longues années. D'autres fois, hâtivement ou en même temps, apparaissent des taches d'achromie, disséminées sans prédilection articulaire, et, tandis que les taches noires restent stationnaires, les blanches croissent rapidement, en peu d'années arrivent même à envahir tout le tégument, ne laissant que la figure, le dos des mains ou des pieds tachetés de peau normale. La peau blanchie par le caraté est souple, non desquamative, ni prurigineuse ; mais les lèvres se crevassent et sont amincies. Il existe aussi quelques plis articulaires, très épaissis. La plante des pieds est en général hyperkératinisée.

ESPÈCE BLANCHE OU LEUCODERMIE PARASITAIRE.

C'est une maladie des villes ou factoreries à température élevée. Elle est peu fréquente et se voit surtout chez des métis. Son début se fait ordinairement entre 18 et 30 ans, par des taches irrégulièrement disséminées, festonnées et qui apparaissent sur les parties couvertes : poitrine, avant-bras ou jambes. Elles s'étendent constamment, et leur marche est relativement rapide. L'apparition est apyrétique et le début passe généralement inaperçu, jusqu'au jour où une personne de l'entourage fait remarquer la leucodermie. En 10 ou 20 ans, toute la peau est prise, et il ne reste que quelques îlots bruns de peau saine, sur la figure, (nez, lèvres, oreilles), au dos des mains ou aux organes génitaux, (pénis, bourses). Parfois le changement est tellement surprenant, et inattendu, que, si l'on n'est pas averti, on se croirait volontiers en présence d'une personne qui a toujours été très blanche, la peau ayant l'aspect presque normal. La peau affectée de caraté blanc est très délicate et s'excorie très facilement, mais n'est pas prurigineuse ni exfoliante. La couleur est rose et d'une blancheur exagérée, qui ne brunit pas par le soleil, comme la peau des blancs de race.

Les lèvres sont en général amincies, desséchées, et très sujettes aux crevasses. Elles sont, de plus, cuisantes par périodes plus ou moins régulières, de même que la peau des mains et des pieds, qui n'est pas hyperkératinisée, mais plutôt amincie et desséchée elle aussi.

Les taches de ce caraté blanc n'ont aucune prédilection pour les régions articulaires et n'observent ordinairement aucune symétrie, dans leur distribution, au contraire de ce qui se produit dans l'achromie secondaire des autres caratés.

Comme dans le caraté rouge, il y a une sensation de sécheresse et même de cuisson, plutôt que de démangeaison, qui assombrit le caractère des malades, en général très irascibles sans raison sérieuse.

Jamais la guérison spontanée n'a été observée. La thérapeutique n'a pas la moindre prise sur le caraté [illegible] ralisé, mais réussit fréquemment à guérir les taches initiales.

FORMES ATYPIQUES

Caraté favoïde.

C'est une maladie très grave, qui coïncide, chez les enfants, avec le favus de la tête. Toute la peau s'exfolie par lambeaux d'un et même de trois centimètres, d'une couleur blanc-sale ou jaunâtre. Le malade dégage une odeur infecte de souris, et est constamment torturé par la cuisson et la brûlure du derme dénudé par la chute de l'épiderme qui tombe sous forme d'écailles très épaisses, qui se soulèvent d'abord à la périphérie et présentent un aspect imbriqué. La maladie très lente au début, peut, dans certaines conditions mal connues, se généraliser à tout le tégument, en n'épargnant que les ongles. Les malades sont forcés d'abandonner tout travail et de s'aliter. C'est une maladie des champs, et spécialement des rizières à température élevée.

L'examen et la culture des squames montre ici une association de l'*Aspergillus* du caraté violet avec une oosporée.

La maladie est presque incurable, et malgré son apparence effrayante, très peu contagieuse, et fort rare.

Caratés trichophytoïdes.

L'aspect clinique est celui des trichophyties des parties couvertes, à marche lente, à durée extrêmement longue et chroniques d'emblée. Les plaques circinées, à bords saillants présentent une couleur violet, rouge ou noir; donnent lieu à une desquamation sèche, et ont une marche excentrique. Elles forment en général un anneau irrégulier dont la peau intérieure est saine, ou à peu près, tandis que la périphérie forme un ourlet ou relief desquamant, qui tranche nettement sur le tégument normal.

Les plaques, généralement en petit nombre, (2 à 4) restent stationnaires, pendant des années; sont très régulièrement arrondies, et localisées aux parties couvertes (dos, cuisses, bras). Leur dimension est en général de cinq à dix centimètres, et elles forment parfois, par leur réunion, des figures circinées, d'aspect géographique.

Les sujets atteints de ces caratés ne présentent aucune maladie parasitaire du cuir chevelu, et ont en général une chevelure luxuriante.

La durée en est très longue. La maladie guérit quelquefois spontanément, surtout chez les blancs, chez qui elle est très fréquente. Plus rarement, chez les mulâtres, elle se généralise, et prend l'allure du caraté violet classique, après être restée un certain temps stationnaire. Le fait s'observe quand le malade abandonne un climat doux pour venir habiter un climat plus chaud, où le caraté est endémique.

Presque tous les individus guéris du caraté violet, et qui reviennent dans les climats où ils l'avaient contracté, présentent, 6 ou 8 mois plus tard, quelques plaques trichophytoïdes violettes, qui, si on ne les soigne pas, reprennent au bout de plusieurs années, la forme généralisée vulgaire des caratés.

On voit très souvent, chez les femmes blanches âgées, des villes à température douce, une grande plaque rouge festonnée, squameuse, saillante et très cuisante, qui reste localisée en général toute la vie, à la figure, à un avant-bras ou à une jambe, et dont le centre est aussi pris que la périphérie. Elle ressemble plus à un lupus érythémateux desquamant qu'à une trichophytie. Les surfaces palmo-plantaires sont presque toujours pleines de petits clous cornés, en tête d'épingle. Ce dernier symptôme distingue ces érythrodermies des lupus serpigineux.

Caraté impétigineux circiné.

C'est une forme rare, rurale, des lieux très chauds. Il ressemble absolument aux grosses croûtes épaisses d'ecthyma vulgaire ; seulement ces pustules croûteuses forment des cercles concentriques sur toutes les parties du corps, (figure, tronc et membres). L'extension aux parties saines encore, se fait en lignes serpigineuses gyroïdes ; la peau qui sépare chaque croûte a l'aspect normal, les malades s'effrayent, le médecin soupçonne la syphilis ; mais le microscope et les cultures montrent que l'on a affaire à un champignon parasitaire très abondant.

Cette forme ne guérit pas spontanément, mais un traitement de quinze jours à un mois à la teinture d'iode, mitigée surtout, en vient à bout. Elle paraît contagieuse par le linge de corps et les vêtements, et même par contact direct. Après la chute des croûtes ecthymateuses, il reste une tache livide ou achromique.

La marche en est rapide et la maladie se généralise en 6 à 12 mois.

Caraté lichénoïde, et psoriasiforme.

La forme lichénoïde ressemble au lichen plan plus ou moins hypertrophique et corné. Généralement, les deux jambes, les deux pieds, les deux mains et les avant-bras sont pris, et il y a une hyperkératose plantaire considérable. Il existe de la cuisson et de la sécheresse, plutôt que des démangeaisons. C'est une maladie des mineurs des régions froides.

Les formes psoriasiques du caraté rouge ont un aspect circiné, pityriasique, plus ou moins figuré. Composées de disques à évolution excentrique, peu desquamantes, elles produisent de grands placards serpigineux, complètement recouverts de grosses squames nacrées, et séparées par des bandes de peau saine. Le prurit est modéré, mais la cuisson devient parfois intolérable. La maladie commence par des petites vésicules très-prurigineuses, très fugaces. A ces vésicules succède un érythème saillant, orbiculaire, qui ne tarde pas à se recouvrir de squames nacrées. En général, les premières taches se montrent :

sur la poitrine, le dos, la nuque, les bras, sans prédilection pour les coudes et les genoux, comme dans le psoriasis vulgaire. La maladie marche assez rapidement, et, en deux ou trois ans, tout le tégument est pris. Elle paraît contagieuse par le linge de corps. C'est une forme assez rare que l'on trouve chez les mineurs.

Sa durée est indéfinie, si on ne la traite pas.

COMPLICATIONS ET GUÉRISON SPONTANÉE

Une espèce de gale chronique complique les vieux caratés violets-cendrés des mulâtres, assez fréquemment, et alors le prurit nocturne devient insupportable et les malheureux vieillards se grattent jusqu'au sang.

Les caratés violets, vieux de 40 à 50 ans, disparaissent spontanément, si l'individu qui les porte est atteint d'une affection fébrile, d'une durée un peu longue, ce qui s'observe fréquemment dans la variole.

Cette disparition et cette mort du champignon parasitaire sont dues, sans doute, au grand développement et à l'activité que prennent, dans les maladies fébriles, les microcoques et bactéries saprophytes de la peau. On peut observer, *in vitro*, que, si l'on sème une colonie d'un champignon de caraté, si d'autre part au même point, on en dépose une autre d'un microcoque saprophyte de la peau, et que l'on mette à l'étuve à 38^oc^ ou 40^oc^, le champignon ne se cultive pas, tandis que les microcoques, en 48 heures envahissent tout le milieu de culture. Si l'on met plusieurs colonies du champignon, quelques-unes commencent à se développer, mais sont bientôt étouffées par les microcoques. Ces microbes paraissent jouer un rôle protecteur de la peau contre les champignons pathogènes.

DIAGNOSTIC

Le diagnostic de tous les caratés en plein développement est facile et le peuple lui même ne s'y trompe pas.

Les taches livides initiales des caratés sont presque toujours confondues avec d'insignifiantes taches de lait, appelées par le peuple, « melancolia » quand elles sont petites et « paños » (en nappe) quand elles sont plus grandes, et qui ne sont, dans ce dernier cas que des taches de caraté, à notre avis. Cliniquement, la différence n'existe pas, et toutes les taches dischromiques, dans les climats à caraté sont suspectes. Mais, tandis qu'une dischromie sans importance, n'augmente ni ne change de couleur, la dischromie des caratés augmente sans cesse, et elle revêt en plus sa couleur caractéristique, quand le terrain est propice. Sinon, elle disparaît spontanément, comme le fait se produit communément, pour les « paños de carate » ou taches initiales, qui se rencontrent très fréquemment chez les jeunes gens de race blanche.

Le pityriasis versicolor à grands cercles, plus ou moins généralisé, se distingue par le signe de la « Desquamativité au coup d'ongle » et parce que la coloration est toujours plus ou moins jaune, chez les blancs, et chez les nègres, d'une couleur argentée ou grise. D'autre part, cette mycose peut se rencontrer associée aux caratés.

Les macules de la lèpre dite tropho-névrotique, peuvent ressembler comme aspect et teinte livide ou violacée aux taches initiales de certains caratés. Mais le diagnostic est facile, parce que dans les caratés il n'y a pas d'altération de la sensibilité comme dans la lèpre, c'est le seul fait important à retenir.

Les dermatoscléroses en plaques peuvent présenter l'aspect de taches récentes de caraté; mais, celui-ci est prurigineux et plus ou moins desquamatif, et la peau, dans les premières années ne s'endurcit pas, tandis que la dureté et l'épaisseur de la plaque blanche de sclérodermie sont caractéristiques et primitives.

Les caratés noirs et violets achromateux ne sont autres que de véritables vitiligos, c'est-à-dire, des dyschromies mixtes, achromo-hypercromiques, qui ne diffèrent pas cliniquement de l'ataxie pigmentaire, décrite ordinairement sous le nom de vitiligo, sauf pour la desquamation, le prurit, la contagiosité dans des conditions spéciales, et la teinte particulière des taches hyperchromiques, qui constituent le caraté proprement dit, parfois très discrètes et petites, et qui, pour un observateur peu habitué à voir des caratés passent sans être remarquées. On peut prendre, par exemple, les achromies carateuses finales, que M. Gomez appelle des caratés « overos » pour des leucodermies, ou achromies cutanées simples. En résumé, les caratés noirs ou violets achromateux sont de véritables vitiligos, dans le sens moderne du mot, comme l'entendent MM. Besnier et Doyon, seulement, ces vitiligos sont parasitaires et leur coloration n'est pas dûe à une ataxie pigmentaire, comme dans le vitiligo simple, mais tant à la coloration propre du champignon causal qu'au pouvoir chromogène de ce champignon. Dans certaines conditions difficiles à apprécier, les cultures de l'*Aspergillus* qui produit le caraté noir-violacé, conserve une couleur blanc d'hermine indéfiniment, au lieu de la couleur brun violacée habituelle ; ou bien la végétation cryptogamique restée noire ou violacée, pendant un certain temps, se couvre plus tard d'un duvet blanc persistant.

Les caratés blancs sont de véritables leucodermies, qui ne diffèrent pas cliniquement des leucodermies simples, congénitales ou non. Ces mêmes leucodermies mycosiques sont contagieuses mais difficilement, et dans des conditions spéciales de terrain et de mode d'inoculation. Elles ne sont pas héréditaires, mais acquises ; et seul l'examen microscopique peut décider s'il s'agit d'une achromie ou leucodermie simple, ou d'un caraté blanc ou leucodermie parasitaire.

Quand à la maladie décrite par le professeur Münch, de Kiew (1) sous le nom de « Vitiligo endémique du Turkestan » (Piès des Sartes), après l'examen des nombreuses photographies de l'ouvrage, on voit que presque toutes représentent des achromies plus ou moins généralisées, sans taches d'hyperchromie apparente, la couleur naturelle de

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1. Münch. *La lèpre au sud de la Russie et le vitiligo endémique du Turkestan*. Kiew 1884-1887. Tome I vol. 3.

la peau étant chez ces peuples brune ou noire. La marche ressemble beaucoup à celle de nos caratés blancs, ou leucodermies parasitaires, qui arrivent à blanchir en quelques années presque tout le tégument externe des mulâtres qui en sont affectés, en laissant quelques îlots bruns de peau normale : sur la figure, le dos des doigts, ou les organes génitaux. Un petit nombre de photographies paraissent montrer quelques taches d'hyperchromie, qui tranchent sur la couleur noire normale de ces individus. Nous citerons par exemple le n° 80 (3ᵉ volume) qui semble représenter un caraté noir-encre de Chine, accompagné d'une achromie abondante. En supposant même, que quelques-uns des individus photographiés présentent quelques taches noir violacé, ces taches ne se verraient pas sur la photographie à cause du faible pouvoir photogène du violet. Nous avons dû nous-même renoncer à la photographie simple, pour nos caratés, parce que les couleurs violettes ou bleues ne viennent pas, ou mal. L'unique procédé applicable à la reproduction des caratés, consiste à colorier, d'après nature, chaque photographie, ou à faire, soit des aquarelles, soit des portraits à l'huile, tous procédés longs, embarrassants et peu pratiques.

M. Münch, dit que cette espèce de vitiligo est considérée comme contagieuse par les Sartes. Les malades sont isolés comme les lépreux.

« La maladie commence sans symptômes prodromaux, « (à l'exception d'une coloration foncée, et d'une démangeaison, locales et cela, seulement dans quelques cas), « par des taches blanches, sans autres changements de

« la peau, lesquelles augmentent en quantité et en volu-
« me, et peuvent envahir tout le corps.

« La maladie peut avoir une marche courte ou lente ;
« la décoloration complète, (la face exceptée) peut être
« terminée en 3 ou 4 ans, ou rester en forme de taches
« disséminées çà et là pour toute la vie.

« La décoloration a certaines lois ; symétrie parfaite-
« ment marquée. Les taches symétriques ne se montrent
« pas cependant simultanément, mais comme des affections
« sympathiques, après un espace de temps plus ou moins
« long (un ou deux ans par exemple).

« Il existe des endroits du corps privilégiés comme
« sièges de décoloration (le dos, les régions sus et sous
« claviculaires etc.) et d'autres, où la teinte normale ne
« disparaît pas, ou disparaît en dernier lieu (face).

« La maladie n'est pas contagieuse. L'hérédité a été
« constatée dans plusieurs cas ».

Comme on vient de le voir, cette description du professeur Münch, transcrite par MM. Besnier et Doyon, dans leurs notes à l'article *Leucodermie et Vitiligo*, de l'édition française de 1891 de l'ouvrage de M. Kaposi, pages 155 et 156 t. II, présente beaucoup d'analogies avec notre caraté blanc ou leucodermie parasitaire et aussi avec nos caratés noir d'encre, quand ils sont accompagnés d'une achromie diffuse plus ou moins étendue. D'autre part ces espèces de caraté, relativement rares chez nous, seraient très fréquentes en Afrique, d'où elles ont été importées en Amérique par les nègres d'Angola.

Des formes atypiques des caratés peuvent ressembler à une trichophytie de la peau dite glabre. Ces trichophyties sont violettes, noires ou rouges érythémateuses, sèches, serpigineuses, ou plus ou moins circinées, à progression excentrique. Un type en est représenté au musée de l'hôpital Saint Louis, au moulage nº 1422 : c'est un caraté noir trichophytoïde de la région ombilicale, contracté en Colombie, au département de Panama ; sujet du service de M. le Dʳ Teneson (1889).

Les caratés prennent la forme trichophytoïde, ou psoriasiforme, quand le terrain n'est pas bien approprié (blancs), et cela révèle un état de souffrance du champignon qui reste ainsi des années. La maladie finit par guérir spontanément. Elle peut donner lieu à la fin à des formes annulaires, figurées, à peau centrale saine.

Les caratés rouges sont ceux qui prennent le plus fréquemment les formes trichophytoïdes annulaires, ou figurées de certains psoriasis, ou de l'eczéma marginé ; ou l'apparence du lupus érythémateux desquamatif, ou même du lupus pernio, par la couleur lilas.

Ce caraté forme, pour ainsi dire, une transition entre les trichophyties chroniques sèches, serpigineuses, à lésions palmoplantaires et plus ou moins généralisées, d'Europe, et les caratés de l'Amérique équinoxiale.

L'érythrodermie innominée que représente le moulage nº 1668 du musée Saint-Louis et provenant du service de M. le Dʳ Besnier (1892) ressemble beaucoup aux caratés rouges localisés, comme couleur, et desquamation.

L'érythème multiforme en nappe, l'érythème pellagroïde même, le lichen plan circiné avec hyperkératose palmo-plantaire ; le pityriasis rubra-pilaire, la dyschromie des adisoniens, etc., peuvent ressembler aux caratés, mais la provenance du malade, la chronicité de la maladie, l'absence de troubles généraux, et en dernier recours le microscope, sont là pour éclairer le diagnostic.

Les caratés à forme ecthymateuse, ou impétigineuse circinée, giroïde, ressemblent à l'impetigo généralisé contagieux.

De même certains caratés peuvent ressembler à des syphilides serpigineuses, psoriasiformes, circinées, érythémateuses ou pigmentaires plus ou moins exfoliantes ; mais les antécédents et au besoin le microscope aideront à fixer le diagnostic.

L'eczéma lichénoïde de la plante des pieds et de la paume des mains ressemble aux lésions de certains caratés ; la coïncidence sur la peau de taches rouges ou violettes du caraté lèvera tous les doutes à cet égard.

Le pinto, jusqu'ici a été confondu avec les caratés. Nous croyons qu'il appartient à la même classe nosologigique que le caraté, comme les trichophyties et les favus par exemple, mais qu'il forme un genre distinct, et par son agent causal, et par sa marche et par quelques symptômes, au moins d'après un bon article de M. Gastambide, qui a su, fort judicieusement en général, extraire des travaux des médecins mexicains, Iryz (1) et Sandoval, la

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1. Voir. *La Indépendencia médica*, T. II, nos 32 et suivants 1881, Mexico. *Memoria sobre la enfermedad pintada de las Américas* » par J.-M. Iryz, de Huimanguillo (Tabasco).

meilleure description que nous ayons du pinto, de ses causes et de sa marche.

Nous transcrivons ce que dit M. Gastambide sur le champignon du pinto du Mexique à la page 261 du n° 33 de la *Presse médicale belge*, 1881.

« En étudiant au microscope des lamelles épidermiques « provenant des parties malades, M. Ruiz y Sandoval et « d'autres médecins, ont pu constater en effet, outre les « différents groupes des cellules polygonales qui constituent les couches profondes de l'épiderme, la présence « de petits corps arrondis, dont les uns, parfaitement « sphériques, mesurent (1) 8 m.m. de diamètre, et les « autres ovoïdes de (2) 6 à 8 m.m. de largeur sur (3) « 10 à 12 de long. A première vue ces corps paraissent tout à fait noirs et polis, mais, sous une certaine « incidence de la lumière réfléchie, ils deviennent, jusqu'à « un certain point, transparents et semblent alors constitués par un très grand nombre de granulations foncées, « suspendues dans un liquide jaunâtre, ou jaune rougeâtre, le tout enveloppé d'une membrane transparente. « Traités par l'acide acétique, ils deviennent plus apparents. Ces corps sont presque toujours accompagnés « d'autres corps, qui ressemblent à des fragments de tubes, « et qui sont souvent si rapprochés qu'ils rappellent, selon « l'expression de M. Sandoval, la disposition d'une queue « de cerise vis-à-vis du fruit qu'elle supporte. Des fragments de ce tube, mesurés par l'observateur, étaient

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1. 8 *m.m* ? nous transcrivons littéralement.
2. Même remarque.
3. Même remarque.

« longs de 18 à 20 mk. sur 2 mk. de large. Ils sont blancs, « polis et brillants, à contours bien limités, et donnant des « reflets cristallins.

« Ils ne présentent sur aucune partie des traces appa- « rentes de dichotomie. Les plus volumineux d'entre eux « sont plus gros à leur base, et vont s'amincissant, pour « se terminer par un sommet tronqué.

« La plupart se terminent par une section comme celle « d'une fracture, quelques-uns par une extrémité bien « régulière.

« A l'extrémité d'un de ces tubes, il a pu observer deux « cellules, dont l'une plus volumineuse, se continuait avec « celui-ci, et l'autre, plus petite, se trouvait superpo- « sée à la première, et semblait en provenir par fissi- « parité.

« La véritable cause de la maladie est donc trouvée. Il « me semble incontestable que nous nous trouvons en « présence d'un parasite végétal, qui, par son implanta- « tion et son développement sur la peau, produit les « lésions anatomiques que l'on constate dans cette affec- « tion ».

Comme on vient de le voir, rien de ce que nous avons trouvé dans les caratés de Colombie ne ressemble au champignon vu par M. Sandoval, sur les squames du pinto. Aussi croyons-nous que, si de nouvelles recherches donnent des résultats dans le même sens, il est évident que le pinto du Mexique n'est pas une espèce distincte de caraté, mais un genre à part. Avec le peu de données connues, et sans la description précise du fruit et des spores, il nous serait impossible de lui assigner une place botanique. M. le professeur Blanchard, croit qu'il s'agirait d'un trichophyton ectothrix, et lui donne le nom de « Trichophyton pictor » (*Traité de pathologie générale*, p. 919, Bouchard).

Dans le même travail de M. Gastambide, nous trouvons : 1° Que le pinto blanc est contagieux, et peut se développer en 48 heures ; 2° que le pinto noir se voit sur les enfants en bas-âge, qui peuvent le donner aux servantes par contagion directe ; 3° Que le pinto se voit sur les nourrissons qui peuvent le communiquer en peu de temps à leurs nourrices.

Je cite ceci, parce que, d'après l'auteur, ce seraient des cas incontestables, rapportés à l'Académie de médecine du Mexique, par un médecin du pays.

Or : 1° le caraté blanc de Colombie, comme tous les autres est chronique, et d'une apparition et d'un développement lents, qui se chiffrent par années et non par heures, comme le pinto blanc du Mexique.

2° Les caratés noirs de Colombie ne se voient pas sur les enfants en bas âge. Ils commencent entre 15 ans, au plus tôt, et 24 ans. Aucun caraté de Colombie, ni noir, ni autre, ne se communique par simple contact, tandis qu'au Mexique, des enfants, atteints de pinto noir, le communiqueraient aux bras de leurs gouvernantes.

3° On ne voit pas de caraté sur les nourrissons, en Colombie ; et une nourrice carateuse ne passe son caraté à son nourrison, tandis qu'au Mexique, non seulement les nourrissons ont le pinto, mais peuvent être contagionnés par leurs nourrices.

Nous pourrions continuer à citer nombre d'autres faits séparant le pinto du caraté, pris dans le travail du médecin belge ; mais cela nous semble inutile. Nous ferons seulement remarquer que tous les auteurs des travaux sur le pinto, ou Teigne du Mexique, (voir Chassin) en ont fait une maladie très contagieuse, par contact direct, et d'un développement rapide relativement au caraté, dont les taches ne prennent la couleur caractéristique qu'un ou deux ans après leur apparition, détail qui explique très bien pourquoi il ne peut se voir chez un nourrisson, même âgé d'un an.

Quand au *cativi*, ce ne serait qu'un pinto d'après un article de M. Arriaga dans la *Caceta de los hospitales de Guatemala* n° 18, juin 1885, traduit et rapporté par M. le Dr Rey dans les *Archives de médecine navale*, T. XLIV, 1885, p. 464. Il dit que c'est une maladie non seulement contagieuse mais héréditaire. Il suffit, pour être pris de *cativi*, qu'un homme sain vienne se baigner en même temps qu'un « manchado », nom donné aux porteurs du *cativi*, ou qu'il se serve d'ustensiles ou d'instruments agricoles, qui sont à l'usage de ce dernier.

Dans la république de Honduras, les « manchados » sont exemptés du service militaire, non par la loi, mais par tradition, en vue d'éviter la contagion parmi les hommes de troupe. Cette dispense constitue une mesure d'hygiène d'une utilité incontestable, d'après l'auteur.

Le *cute* de Venezuela a un début aigu et fébrile, d'après Freitez, cité par M. Gomez dans sa thèse de Paris. Quelques auteurs ont mis en doute un pareil début. Mais M. Legrain, dans un article publié dans le n° 1 des *Archives de parasitologie* du 1er janvier 1898, appelle l'attention sur des dermatoses du Sahara très semblables au pinto du Mexique, mais dont le début est aigu et fébrile, comme celui du *cute.* L'auteur insiste sur cet état fébrile, qui est constant, ne peut être attribué à une autre cause, et fait bien partie de la maladie. D'autre part, il dit qu'il n'a pas trouvé, dans les squames, le champignon de Sandoval, ni aucun autre.

Il paraît donc qu'il existe des dermatoses semblables au caraté, par l'aspect, mais cliniquement et bactériologiquement différentes. A en juger par le début bruyant, il s'agirait plutôt d'une affection microbienne.

PRONOSTIC

Le caraté complètement développé est difficile à guérir. S'il a plus de 30 ans, il est non seulement difficile, mais même dangereux de le traiter, parce qu'en général, il occupe tout le tégument externe. Le caraté de 1 à 5 ans, guérit facilement.

La guérison du caraté, à l'état de « paños » d'achromie initiale, est la règle. Elle survient spontanément, surtout chez les blancs. Les achromies péri-articulaires des caratés anciens sont des lésions définitives et incurables, en général.

Le caraté rouge, violet pur, ou violet rougeâtre est plus grave dans les classes travailleuses qui vivent de leurs mains, en quelque sorte, parce que les crevasses profondes, et les callosités palmo-plantaires sont accompagnées, non seulement de cuisson ardente, mais dans certaines occasions, par suite d'infections secondaires, de douleur insupportable, et même de lymphangites tenaces. Il en est de même chez les muletiers, qui font de grands trajets et que les crevasses plantaires forcent à abandonner leur place, et à monter à cheval derrière leurs bêtes.

Tous les caratés, mais surtout le rouge aigrissent le caractère, et les carateux sont irascibles en règle générale, et ne supportent aucune allusion à leur mal, qui les dégoute eux-mêmes, et les prive de leurs relations sociales, surtout pour les dames de famille honorable.

Le Dr Uribe Angel, qui a été à même de bien étudier leur état moral, s'exprime ainsi : « Le caraté est une in-« firmité grave, mais non mortelle. Elle est grave, parce « que ceux qui en sont atteints, traînent une existence « mortifiée et gênée. Le « caratejo » est en quelque sorte « hors la loi sociale, parce que le peuple pense que la « maladie est contagieuse à un haut degré. On le fuit, on « évite autant que possible son contact, si bien que le « malheureux, connaissant l'état râpeux de ses mains, « l'aspect repoussant de sa personne et l'idée générale « que l'on a de la nature de sa maladie, devient en quel-« que sorte honteux et timide, dans ses relations avec le « monde ».

Les médecins du pays croient que certaines affections inflammatoires sont plus graves chez les carateux, et M. Uribe y fait allusion en disant :

« Il y a sans doute, chez eux, quelque chose de parti-« culier dans le tube digestif. Car j'ai cru remarquer que « toute maladie inflammatoire chez eux a une influence « funeste sur la guérison. La dysentérie surtout est pres-« que toujours mortelle ».

L'état de dégoût des carateux et surtout leur facile irascibilité font que le nombre des rixes et des homicides dans les factoreries minières (grands foyers de carateux) atteint un nombre considérable. Cette modification du caractère due à la maladie, est, au point de vue moral, sociologique et judiciaire très importante. Les juges devraient, en tenir compte comme de causes atténuantes.

maïs pourrait, au moins dans les terres froides, être remplacé par le blé.

Un fait admis par tous, est que le caraté généralisé est bien plus difficile à guérir, et, qu'en supposant qu'on le guérisse, les récidives sont la règle, parce que les malades, qui, en général, ont leur famille et tout leur avoir dans des localités où le caraté est endémique, ne se soumettront pas à abandonner leurs champs et leur situation, pour émigrer dans un climat moins favorable au champignon pathogène. De plus les individus, nés et élevés dans les régions chaudes qui entourent les grandes rivières, n'aiment pas les climats froids et ne s'y trouvent pas bien. Le plus convenable et le plus logique est de traiter la maladie, dès qu'elle apparaît, et quand elle est limitée à une ou deux taches. C'était aussi l'opinion d'Alibert, qui dit : « Feu M. Zea prétendait qu'il n'était pas possible de « s'en rendre maître, quand la maladie avait fait certains « progrès. Il est donc important de la combattre aussitôt « qu'elle paraît ».

Toute tache de caraté, qui ne date pas de plus de 6 mois à un an, cède facilement à l'application journalière de teinture d'iode pure ou coupée du double d'alcool. Si les taches sont plus vieilles, et occupent tout un membre, la teinture d'iode n'a pas une grande action, et on doit la remplacer par la traumaticine à la chrysarobine, en ayant soin de prendre avant un bain tiède avec du savon noir ou au bichlorure de mercure, et répéter tous les 4 jours pendant 15 jours. Plus tard, une application de traumaticine, tous les 8 jours suffira. Le traitement terminé, la végétation cryptogamique a pour ainsi dire complètement disparu ; mais la peau reste squameuse et rude avec un certain aspect icthyosique. Pour lui rendre son aspect normal, il suffit de quelques bains locaux émollients de son ou d'amidon, ou simplement d'une onction journalière avec un peu de vaseline ou de beurre de cacao.

L'aspect de la peau est complètement redevenu normal deux ou trois mois après ce traitement. Si les malades, ainsi guéris, reviennent dans des foyers de caraté, il se produit, en général, 6 à 8 mois après, une ou deux plaques de caraté franc, ou trichophytoïde, que l'application de traumaticine à la chrysarobine guérit ordinairement en 15 jours.

Au lieu d'appliquer le mélange de chloroforme, de gutta-percha et de chrysarobine, il vaut mieux appliquer d'abord la chrysarobine, dissoute dans le chloroforme, puis ensuite, quand cette première couche est sèche, appliquer avec un pinceau, la gutta-percha dissoute dans le chloroforme.

La formule que nous employons est la suivante :

N° 1.

Chrysarobine	10 gr.
Chloroforme.	90 gr.

Appliquer avec un pinceau et laisser sécher.

N° 2

Gutta-percha.	10 gr.
Chloroforme.	90 gr.

f. diss.

Passer avec un pinceau une couche régulière sur tout le premier vernis de chrysarobine.

pensable, mais vaudraït mieux. En général, il suffirait de changer de linge tous les huit jours.

Pour une guérison définitive, il est indispensable que les patients changent de climat pour un plus doux, et où ne règne pas la maladie. De plus, certaines professions doivent être abandonnées.

CONCLUSIONS

1° Les caratés les plus fréquents en Colombie sont des *aspergilloses* de la peau. Ces *Aspergillus* appartiennent, pour la plupart, à des espèces innominées.

2° Quelques unes de ces moisissures se trouvent à l'état saprophytique dans la nature.

3° Les moustiques du genre *Simulium* et les punaises des foyers à caraté véhiculent les spores de quelques espèces de moisissures caratogènes, et peuvent les inoculer à l'homme.

4° Les milieux glycérinés sont les meilleurs pour la culture des champignons des caratés.

5° Ces moisissures se cultivent bien sur des milieux contenant du sulfate de fer, de cuivre, et même de zinc.

6° Des inoculations sur les animaux (lapins) semblent reproduire la maladie. Ces caratés artificiels donnent une dépilation hâtive et étendue accompagnée d'une desquamation plus ou moins intense. La teinte que le champignon communique à la peau s'étend parfois aux poils, pendant un certain temps; finalement peau et poils reprennent leur couleur normale. La marche des taches carateuses artificielles est excentrique, et la périphérie se prend, tandis que la partie centrale guérit.

7° Chez l'homme, (mulâtres) l'inoculation paraît positive, mais, comme il faut guérir les taches peu de temps après leur début, l'observation reste incomplète.

8° La couleur des caratés est en rapport avec celle des champignons pathogènes, et aussi avec le pigment qu'ils sécrètent, dans des conditions spéciales.

9° Une hygiène appropriée pourrait limiter considérablement la propagation des caratés.

10° Les caratés au début guérissent facilement.

11° Les taches dischromiques appelées par le vulgaire « paños » et considérées comme de simples taches de lait insignifiantes, sont le vrai début des caratés et doivent être soignées le plus tôt possible.

12° Les caratés généralisés sont très difficiles à guérir d'une façon complète et définitive.

13° Le traitement doit être continué quelque temps après la disparition apparente de la maladie.

OBSERVATIONS

CARATÉS VIOLETS.

Observation 1

B. L..., mulâtre de 32 ans, naquit à Sopetran et travailla comme journalier l'agriculture et la minerie dans des climats chauds comme Zaragoza et Remedios.

Ni ses parents, ni ses frères, n'ont présenté de caraté, et seulement quelques-uns de ses oncles en sont affectés.

Antécédents syphilitiques probables.

Interrogé sur la manière dont lui commença le caraté, il dit : dans mon enfance, et jusqu'à l'âge de 22 ans, j'avais la peau en parfait état et sans aucune tache ; mais après apparut une tache blanchâtre et livide sur mon front, laquelle disparut promptement, traitée avec de la pommade citrine.

Quelques mois passèrent et des taches semblables se présentèrent sur les jambes, mais qui n'étant pas traitées, prirent une couleur violette et se généralisèrent sur toute la peau.

Le malade étant déshabillé, on voit ceci : taches blanches, livides, violacées et violettes, de dimensions distinctes plus ou moins contiguës les unes aux autres, séparées par des intervalles de peau saine, ou bien unies, festonnées, formant comme un dessin de carte géographique. Ces taches prédominent sur le visage, les épaules, le dos des mains, les jambes et le dessus des pieds. La pointe du nez présente une tache violette dont l'hyperchromie unie à la dischromie livide ou couleur de fumée des autres petites taches disséminées sur le visage, donnent à cet individu l'aspect d'un arlequin.

Les épaules présentent des taches de coloration distincte. On voit, en effet, au niveau des régions supra-scapulaires, des taches de contours sinueux et festonnés, de couleur violacée au centre et pâle sur la périphérie. Sur les régions claviculaires, on remarque de grandes taches d'une couleur violet foncé.

Sur les membres supérieurs, on voit deux grandes taches violettes qui s'étendent de la moitié inférieure de l'avant-bras jusqu'aux doigts, excepté au niveau de l'extrémité inférieure du radius, du cubitus et des méta-carpiens, où se trouvent des taches blanc-rosé d'achromie complète. Les jambes présentent des taches violettes ; à leur niveau tous les poils manquent. Les chevilles sont maculées de blanc-rosé. Sur le genou gauche, on voit un ulcère serpigineux, peu profond, d'un contour violet foncé. Les plantes des pieds sont sèches et fendues.

Le malade dit que toutes les taches, et spécialement celles des jambes, sont prurigineuses.

Observation 2

A... Lopez, mulâtre, de 16 ans, natif de la ville d'Antioquia et agriculteur de profession.

Son père a le caraté violet, sa mère et ses frères n'en sont pas atteints.

Jeune homme robuste et sans antécédents pathologiques particuliers.

Les membres supérieurs présentent de multiples taches de caraté d'un violet-cendré. Celles-ci occupent la partie postéro-inférieure des bras, les coudes et les deux tiers inférieurs des avant-bras. Ces taches sont festonnées et présentent un aspect différent selon la région qu'elles occupent et leur période d'évolution. Ainsi, sur les coudes, au niveau de l'apophyse olécranienne, il y a achromie complète, mais au dehors, la coloration est violette, et complètement sur la périphérie, la teinte est pâle-fumée. Les taches des avant-bras sont plombées, plus ou moins cendrées.

Sur les membres inférieurs leur distribution est comme suit : la face dorsale des pieds, les deux tiers inférieurs des jambes les genoux et les deux tiers inférieurs des cuisses.

Ces taches diffèrent aussi d'aspect selon leur place et l'époque de l'apparition : sur les malléoles internes et externes il y a achromie complète ; sur les jambes, de grandes taches violettes, desquamatives et la peau est sèche, comme cartonnée et épaisse ; sur les genoux il y a de petites taches d'achromie.

La nuit, le prurit est marqué dans les jambes et les avant-bras.

Observation 3

D... Avendaño, métis de 30 ans, natif de Sopetran et journalier de profession.

Ses parents et ses frères n'ont pas de caraté.

Il y a 10 ans, apparurent sur la figure quelques taches livides qui devinrent légèrement bleues.

L'examen extérieur montre : sur le visage,sur les pommettes des taches d'un violet-bleuâtre, de même que sur la partie inférieure du front et sur la lèvre inférieure ; sur d'autres points des petites taches bleues et livides.

Sur les membres supérieurs les taches occupent les deux tiers inférieurs des avant-bras, les coudes et la partie dorsale des mains. Aux coudes ces taches forment une espèce de cocarde tricolore ; au niveau de l'olécrâne, une tache blanche d'achromie complète, autour un anneau violet et plus en dehors un cercle irrégulier d'une couleur bleu-clair.

Au niveau des extrémités inférieures du radius et du cubitus, achromie entourée par une zone bleuâtre.

Sur les membres inférieurs : taches violettes furfuracées aux jambes ; achromie sur les malléoles et autour de cette achromie un anneau irrégulier de couleur violet-foncé.

Observation 4

Maria T. G..., mulâtresse de 45 ans, native de Médellin et cuisinière de profession.

Ses parents n'ont pas de caraté.

Elle a eu plusieurs attaques de rhumatisme, une de dyssentérie et une fièvre typhoïde.

Cette femme dit avoir fait un voyage à Sopetran, où elle demeura deux ans, sans avoir remarqué aucune tache sur la peau ; mais peu de temps après son retour à Médellin, elle remarqua quelques taches couleur de fumée sur les pommettes, qui, quatre mois après, devinrent violettes.

Aujourd'hui elle présente sur les petites articulations des mains des petites taches acromiques, et sur les poignets et les cou-de-pieds, des anneaux blancs d'achromie complète ; la peau sur ces points est lisse et d'une épaisseur normale, non prurigineuse.

La langue, la muqueuse labiale et gingivale, présentent des taches d'un violet brun. La langue et les lèvres n'ont pas de crevasses.

Observation 5

Claudina V..., mulâtresse de 30 ans, native de Sopetran et cuisinière de son état.

Ses parents n'ont pas de caraté, mais quelques oncles en ont.

Elle a souffert de rhumatismes et de névralgies. Sa menstruation est difficile, accompagnée de coliques utérines et ne dure qu'un jour.

D'après ce qu'elle dit, depuis son très jeune âge, elle présente sur les mains et sur les pieds quelques petites taches blanches, placées sur la peau des petites articulations des doigts.

Examinée aujourd'hui, on remarque ce qui suit : de grandes taches achromiques qui recouvrent le dos des mains et le tiers inférieur des avant-bras ; ces taches sont symétriques et gardent une certaine ressemblance dans leur forme à contours sinueux. Ces dites taches sont d'un blanc rosé ; la peau n'est pas atrophiée et il n'y a pas de prurit, ni aucune cuisson.

Sur certains points ces plaques sans pigment sont entourées de petites taches violettes furfuracées, très discrètes. Les coudes et la partie interne des bras présentent de grandes plaques blanches, lisses et semblables à la peau des enfants par leur douceur.

Le dessus des pieds est presque tout blanc, avec quelques points d'un violet brun ; les cou-de-pieds sont entourés de larges anneaux achromiques, rugueux. La partie antérieure des jambes présente de grandes taches blanches qui vont en montant jusqu'aux genoux où elles se divisent en plusieurs, plus petites, séparées par des intervalles de peau saine ; sur la partie inférieure de la cuisse les petites taches sont d'un blanc sale comme des taches de rousseur.

Vers la partie externe des pieds, on voit quelques taches violettes, sèches et fendues par intervalles, couvertes de quelques grosses écailles. Les plantes sont calleusés, sèches et pleines de fissures dans divers sens.

Les taches violettes et les plantes des pieds se dessèchent et produisent une sensation de brûlure, par époques qui durent un mois ; puis, l'ardeur et la sècheresse disparaissent.

La malade dit que les taches blanches augmentent lentement, mais constamment, d'année en année.

Observation 6

José Maria G... mulâtre de 40 ans, journalier, est natif de Fredonia.

Ses parents et ses frères ne présentent pas de caraté ni aucune autre maladie de la peau.

Il a souffert des fièvres paludéennes contractées dans les fermes du fleuve Cauca où il travaillait habituellement.

Il y a quinze ans, il remarqua sur le dos des pieds des taches violettes qui prédominaient surtout vers les bords internes et externes, et qui à mesure qu'elles s'étendaient, perdaient leur couleur violacée dans plusieurs endroits, la peau restant blanche, et dans d'autres, la teinte violette se faisait plus sombre. Bientôt apparurent d'autres taches violettes lisses au tiers inférieur des jambes, alternant avec d'autres, livides ou de couleur bistrée.

Le malade présente aujourd'hui une achromie complète des petites articulations des mains et des pieds, et de grands cercles blancs, sinueux et irréguliers sur les cou-de-pieds et sur les régions radio-carpiennes. Sur ces dernières articulations l'achromie prédomine du côté palmaire qu'elle envahit en partie.

Sur le visage, il présente sur les pommettes deux taches violet-brun orbiculaires. Les muqueuses : labiale, gingivale et géniales montrent des taches lisses d'un violet-brun, séparées par des intervalles de muqueuse saine.

Sur la jambe droite on voit une ulcération à contours circinés, desquamatifs, violet-foncé. La dite ulcération est non-douloureuse, mais ses bords sont très prurigineux par époques. Le malade dit qu'il y a un an à la suite d'une déchirure avec une branche, au centre d'une plaque de caraté, il apparut une petite solution de continuité rebelle à tout traitement et qui est allée en augmentant lentement et progressivement sans aucune tendance à la guérison.

Les taches de caraté que cet individu présente aujourd'hui ne sont ni desquamatives, ni prurigineuses. Les plantes des pieds sont calleuses et fendillées, mais non douloureuses, et ne le gênent absolument pas pour la marche, que ce mulâtre comme tous les autres hommes du peuple effectue avec les pieds nus ou, au plus, avec une espèce de sandale nommée ici *abarcas*, quand elles sont de cuir, ou *alpargates*, quand elles sont de fil d'agave et de coton.

Observation 7

Fabriciano L..., mulâtre de 20 ans, agriculteur de profession et natif de la ville d'Antioquia.

Ses parents n'ont pas de caraté. Paludéen et de constitution faible.

Il y a deux ans, il lui apparut sur la joue gauche une tache couleur de fumée à centre violacé ; peu après d'autres taches plus petites, dischromiques ou d'un violet-clair envahirent l'aile des narines, la partie inférieure du front, la nuque et la face antéro-supérieure des oreilles.

Des taches semblables se montrèrent symétriquement sur le dos des mains, ensuite sur le dessus des pieds et sur la partie inférieure des jambes et enfin sur les épaules.

Quand les taches de la figure apparurent (il travaillait comme charretier dans les mines de Barbosa), on les traita avec une solution alcoolique de sublimé corrosif ; elles disparurent presque complètement, mais il n'en fut pas de même de celles des mains et des pieds, qui après avoir disparu à demi, reparurent avec plus de force envahissant une plus grande étendue de peau saine.

L'examen du patient montre ceci : sur la joue droite une tache livide de trois centimètres. Sur le dos des mains une tache violet-cendré, desquamative, criblée de points blancs correspondant aux cinq extrémites inférieures des métacarpiens. La peau qui recouvre les extrémités inférieures du radius et du cubitus est blanc-rosé et lisse. Ces taches blanches sont non seulement symétriques, mais elles gardent une régularité remarquable dans leur forme géométrique. La peau des coudes présente des taches parfaitement orbiculaires et tricolores, le centre est blanc-rosé, lisse, puis un cercle violet-cendré, desquamatif et enfin une zone circinée, pâle qui va en se dégradant jusqu'à se confondre avec la peau normale.

Les pieds sont violet-cendré, desquamatifs et crevassés. Les jambes présentent des taches violet brun de desquamation abondante, qui alternent avec d'autres pâles et de couleur fumée.

Les genoux commencent à présenter des petites taches irrégulières d'achromie entourées par de grandes plaques cendrées, desquamatives.

Sur le dos on voit des plaques gigantesques à contours géographiques d'une couleur violet-cendré et luisantes comme si on y avait passé une couche de collodion. Ces taches alternent avec des intervalles de peau saine et avec d'autres petites taches d'une couleur fumée ou gris-cendré.

La desquamation est abondante et le prurit intense le soir en se couchant.

Observation 8

Benancio V.... mulâtre de 22 ans, naquit à Medellin et fut élevé sur les rives du fleuve Cauca, où il a travaillé depuis l'âge de 8 ans comme journalier dans les fermes de troupeaux.

Jeune homme de constitution vigoureuse, sans antécédents syphilitiques héréditaires ni personnels.

Il a souffert de fréquentes attaques de malaria.

Il y a un an et demi se montra sur sa jambe droite une petite tache de caraté bleu, qui s'étendit circulairement jusqu'à former un anneau complet.

Dans certaine occasion, étant demeuré tout un jour les jambes dans l'eau d'un ruisseau, le soir en se couchant, il commença à éprouver une douleur et une sensation d'ardeur à ce niveau ; deux jours après apparurent sur la tache de caraté de petites vésicules pleines d'un liquide transparent ; les dites vésicules se rompaient et répandaient constamment une eau claire assez abondante, surtout quand il marchait. Ces vésicules sont allées en s'ulcérant profondément. Après sept mois, sur cette partie, sont apparues des petites tumeurs grosses comme une cerise; ces tumeurs apparaissent et augmentent pendant vingt ou trente jours; ensuite elles s'ulcèrent et suppurent et enfin elles restent stationnaires, répandant un liquide clair complètement inodore. Leur durée est longue et si la guérison survient spontanément, elles laissent une cicatrice profonde, déprimée, irrégulière et indélébile.

ASPECT EXTÉRIEUR.

Tout le revers du pied droit et la partie antérieure de la jambe sont semés de tubercules de taille distincte, quelques-uns ulcérés, de fond pultacé. Ces petites tumeurs alternent avec des cicatrices déprimées et de grosses écailles nacrées, psoriasiques, qui décrivent une limite de contours circinés et sinueux.

Sur le genou du même côté, on voit des cicatrices gaufrées et irrégulières, entourées d'abondantes écailles; les tubercules suppurés sont couverts de croûtes ecthymateuses, nacrées et qui lui occasionnent un prurit intense pendant la nuit.

Sur le coude droit, on voit une tache violet-brun, serpigineuse, recouverte de grosses écailles nacrées, et en outre quelques petits tubercules non ulcérés. Cette plaque est très prurigineuse pendant la nuit dans certaines occasions.

Le malade ne peut pas travailler et la marche lui cause de la douleur dans les tubercules ulcérés.

Actuellement ce malheureux vit de la charité publique.

Observation 9

Brigido B..., métis de 58 ans, natif de Bello.

Il présente une paraplégie spasmodique d'origine spécifique, depuis 14 ans.

Il y a vingt ans, apparurent des taches violacées sur les pommettes et sur la partie inférieure du front. A cette époque il travaillait comme péon dans les mines de Remedios.

Ses ascendants n'ont pas eu de caraté ; son épouse a la même espèce de caraté que lui.

Aujourd'hui, il présente sur la partie antéro-inférieure des avant-bras et la paume des mains des taches énormes, festonnées, de couleur blanche, et sans la moindre desquamation ni aucun épaississement de la peau ; les dites taches se terminent nettement, sans transition avec la peau saine.

Sur le dos des mains on voit de légères petites taches d'une couleur violet pur et furfuracées.

Aux jambes et aux cuisses de grandes plaques blanches alternent avec d'autres violettes, desquamatives et qui sont séparées par des petites bandes de peau saine.

Les taches violettes sont très prurigineuses dans le membre inférieur droit, mais non dans le gauche, parce que celui-ci est anesthésique.

Le gland présente une tache de caraté blanc, de même que la région inguinale gauche. Le visage montre plusieurs taches violettes plus ou moins fusionnées et non desquamatives. Sur la poitrine et l'abdomen on remarque de grandes taches de caraté blanc, aux contours festonnés et géographiques. Lé dos présente des taches blanches, mais moins grandes que celles de l'abdomen. Les bras aussi sont affectés.

Il faut remarquer que les taches violettes des membres sont plus ou moins desquamatives et pruriginеuses, tandis que les blanches, distribuées irrégulièrement sans aucune prédilection pour les régions articulaires, sont lisses, avec la peau douce, et jamais pruriginеuses.

Les articulations couvertes de peau blanche l'ont été par propagation secondaire et non par l'apparition primitive sur les parties osseuses saillantes, des taches achromiques qui accompagnent ordinairement les caratés.

Cet individu montre donc deux espèces de caratés, le violet qui parut d'abord, et le blanc vrai, qui parut peu après sur d'autres points de la peau qui n'avaient pas encore été touchés par le caraté violet.

Le malade étant examiné avec attention, on voit que les deux espèces de taches évoluent parallèlement, sans donner les unes origine aux autres, et sans que les blanches, soient une régression finale des violettes. En outre, tandis que les taches violettes apparues les premières sont restées stationnaires, les blanches, leucodermiques croissent et envahissent la peau saine lentement, mais d'une manière indéfinie.

Observation 10

Juan B. H..., mulâtre, âgé de 30 ans, agriculteur, natif de Betulia.

Ses parents et les autres membres de sa famille n'ont pas de caraté, de trichophytie, ni aucune autre maladie de la peau ou du cuir chevelu. Il ne se souvient pas d'avoir eu aucun animal domestique avec la teigne.

Cet homme a souffert des fièvres intermittentes, et il a eu la fièvre typhoïde il y a un an.

Il y a huit ans apparurent des plaques orbiculaires, érythémateuses, crevassées et douloureuses sur les jambes. Un an après, des taches semblables se montrèrent sur le front, envahissant par propagation une partie du cuir chevelu, mais sans affecter notablement les cheveux. Deux ans plus tard, les dites taches apparurent sur les membres supérieurs.

Etat actuel. — Santé générale bonne. Sur les jambes, les cuisses et les hanches, de même que sur les bras et les avant-bras, il présente des plaques érythémateuses à bords saillants, en relief,géantes, circinées, qui progressent excentriquement, laissant un centre de peau saine; la desquamation est superficielle et modérée, la coloration de ces taches est lie de vin ou violette, excepté sur les bords qui présentent une couleur rougeâtre d'érythème.

Ces taches commencent par un petit bouton squamulaire qui, en croissant forme des plaques orbiculaires qui, s'unissant les unes aux autres, prennent un aspect serpigineux et sec.

Tous les poils des régions affectées ont disparu.

Le prurit est intense et le malade se gratte jusqu'à faire jaillir le sang. Par époques, il sent dans ces régions une sensation d'ardeur comme une brûlure.

Les parties découvertes sont saines, de même que la tête qu conserve une chevelure abondante.

CARATÉ NOIR-VIOLACÉ.

Observation 11

Pedro A..., nègre de 60 ans, natif de Remedios et mineur de profession.

Ses parents et ses frères n'ont pas de caraté.

Dès l'âge de 25 ans commencèrent à se montrer quelques taches gris-cendré et noires sur l'avant-bras gauche. Les dites taches allèrent croissant et se disséminant sur tout le membre gauche, laissant seulement quelques intervalles de peau saine.

Ensuite apparurent sur l'avant-bras droit, et plus tard sur les jambes, ces mêmes taches.

Etat actuel. —Le malade, de constitution vigoureuse, présente plusieurs taches blanches au niveau de toutes les petites articulations des mains (partie dorsale).

De grandes taches achromiques sur la partie antéro-inférieure des avant-bras ; ces taches sont complètement symétriques. La peau de ces taches est douce et blanc-rosé comme la peau d'un enfant ; les poils manquent sur toutes les taches.

A côté des taches achromiques du poignet, on en voit d'autres petites, de couleur noir de plomb, desquamatives e crevassées à intervalles, présentant à défaut de poils une multitude de petits trous de la grosseur d'une tête d'épingle. Sur la partie postérieure des avant-bras, on voit des taches noires et d'autres plus petites à reflets violets : sur quelques points, on aperçoit des petites taches dischromiques d'un gris de fumée.

Sur les membres inférieurs, le malade présente de grandes taches noires et cendrées, desquamatives et sèches, qui lui occasionnent beaucoup de prurit, surtout pendant la nuit.

Le dessus des pieds montre quelques petites taches d'achromie. Les plantes sont coriacées, calleuses, sèches et fendues.

Sur le tronc, on voit des macules noires ou céndrées, séparées par des intervalles de peau saine.

Depuis quatre ans il lui est apparu une tache noire sur le nez, laquelle se propage lentement sur les joues, présentant la forme d'un papillon les ailes ouvertes.

Les lèvres sont tachées d'un violet brun. Tout l'intérieur de la muqueuse bucco-pharyngienne est tacheté de petites macules violet-brun.

La partie dorsale de la langue est crevassée et présente une tache irrégulière de couleur violet-brun ; le malade dit qu'auparavant il ne l'avait pas et qu'elle ne lui est apparue que ces dernières années sans affecter en rien ni son goût ni sa déglutition.

Observation 12

C..., Arenas, nègre, âgé de 18 ans, journalier, originaire de Fredonia, a passé presque tout son temps sur les rives du fleuve Cauca.

Sa mère présente la même espèce de caraté et celui-ci occupe plus ou moins les mêmes points. Il a souffert des fièvres paludéennes. Dès sa plus tendre enfance, il montra des petites taches blanches sur les articulations des mains et des pieds.

Aspect extérieur. — Il présente sur le dos des mains, vers l'extrémité inférieure des métacarpiens, quelques taches d'achromie qui alternent avec des espaces de peau saine ou d'un violet-brun. Sur la partie inféro-antérieure des avant-bras, il y a deux grandes taches d'achromie qui prédominent vers le bord cubito-palmaire. Aux coudes, on remarque deux taches achromiques de la grandeur d'un franc, entourées d'autres petites taches blanches, le tout cerclé par une large zone violet-plombé, très desquamative et sèche. Sur le pli du coude droit, on voit une grande tache noire.

Les cou-de-pieds ont de larges anneaux achromiques, symétriques et gardant une certaine ressemblance de forme.

Ces plaques blanches sont entourées par d'autres d'un noir-plombé, desquamatives et à intervalles violacés. Les jambes sont envahies, à la manière des vieux arbres par les lichens, par des taches noires ou cendrées, serpigineuses qui au niveau des genoux sont interrompues par plusieurs taches d'achromie assez petites.

Ces taches des jambes sont très prurigineuses la nuit.

Observation 13

Francisco B..., métis de 55 ans, natif d'Armenia et ouvrier dans des mines de chaux.

Ses parents et ses frères ont le caraté noir-violacé.

Actuellement, le caraté de cet individu a l'aspect suivant : sur le nez, les pommettes, la partie antéro-supérieure des oreilles, des taches noir-violacé qui donnent à la physionomie un certain air badin et carnavalesque ; ces plaques sont furfuracées ; elles parurent il y a 15 ans et il les attribue à des moustiques qui le piquaient et qu'il écrasait dans les susdites régions quand il était en train de travailler. La nuque et le cou présentent plusieurs taches noires, lisses. Sur la poitrine, on voit une bande noire, de trois centimètres de largeur, qui s'étend de la partie supérieure du sternum à l'appendice xyphoïde. Aux coudes se remarquent de grandes taches noir-violacé avec trois points achromiques au niveau de l'olécrâne, de l'épitrochlée et de l'épicondyle.

La peau du tiers supérieur de l'avant-bras est normale, mais celle des deux tiers inférieurs présente une grande plaque noire, limitée par une bande blanche dans la région palmaire du poignet. Le dos des mains a sur toute son étendue le caraté noir avec des taches achromiques sur les parties saillantes des articulations métacarpo-phalangiennes et de la première avec la deuxième phalange.

La paume des mains montre un commencement d'achromie.

Les deux jambes ont le caraté noir-violacé et la peau du tiers inférieur, de même que celle des malléoles et des talons présente une épaisseur considérable ; elle est sèche, cartonnée et couverte de grosses écailles d'un gris-sale.

Le dessus des pieds a des taches violet-brun qui alternent avec l'achromie des articulations.

La muqueuse labiale et buccale présente diverses petites taches violet-brun.

Observation 14

Léon R..., nègre, natif de Anzà, âgé à peu près de 45 ans, batelier de profession dans le port de Caramanta du fleuve Cauca.

Ses parents furent atteints de caraté.

Le caraté commença chez lui, vers 25 ans, par quelques taches de couleur violet clair, sur les pommettes ; plus tard d'autres taches semblables parurent sur divers points du tégument externe. Dans la partie centrale de quelques-unes de ces taches se montrèrent des taches blanches qui allèrent s'unissant jusqu'à former des plaques achromiques de grande taille.

Le malade présente aujourd'hui ce que le Dr Gomez appelle *carate overo*, c'est-à-dire, de grands intervalles de peau dépigmentée et complètement achromique, au niveau des genoux, des coudes, des os des chevilles, des trochanters, des fesses et du scrotum.

Les taches violettes qui restent sont petites et très discrètes, et seulement un examen attentif les fait remarquer ; ces petites taches hyperchromiques se rencontrent sur la périphérie de quelques énormes taches blanches.

Le gland présente une tache violet brun et lisse. Les muqueuses, labiale, linguale et palatine présentent aussi plusieurs plaques violettes et lisses.

Chez les gens de cette profession affectés de caraté (rameurs des grands fleuves des climats chauds) il est très fréquent de voir une achromie articulaire précoce et qui forme des plaques blanches considérables, sur le développement desquelles influe certainement le contact constant ou très fréquent de l'eau qui macère l'épiderme et débilite sa résistance.

Observation 15

Cesario E..., nègre de 66 ans, natif de Santarosa a passé la plus grande partie de sa vie travaillant comme péon dans les mines de Remedios.

Un de ses frères présente le caraté noir violacé, ses parents ne l'ont eu d'aucune espèce.

A l'âge de 18 ans apparut une tache noire farineuse sur l'avant-bras droit ; quelques années plus tard des taches semblables avaient paru sur d'autres points.

Il a été paludéen.

Le malade, de constitution vigoureuse, montre sur les membres supérieurs et inférieurs de grandes taches noir plombé, très desquamatives et prurigineuses; les dites taches sont séparées par de petits intervalles de peau saine. Sur la partie inférieure de l'avant-bras gauche, il présente un anneau irrégulier d'achromie et le même se voit du côté droit avec une grande symétrie et ressemblance géométrique.

La peau de la poitrine et de l'abdomen est desquamative et maculée abondamment de noir; ces taches sont hérissées de points saillants comme des têtes d'épingles, à défaut de poils qui tous ont complètement disparu faisant contraste avec la peau saine qui en est abondamment garnie. Sur le dos, on voit des plaques noires géantes, desquamatives ; dans la partie centrale de celles-ci et sur les apophyses épineuses se remarquent deux taches achromiques, aux contours irisés et violets.

Ce malade présente sur les lèvres et sur la langue des petites macules violettes de la largeur d'une lentille ; la langue montre des crevasses transversales, mais qui n'occasionnent aucune douleur.

Les oreilles ont des petites taches lentigineuses, violettes Sur le nez, on voit une tache violet brun qui s'étend et s'agrandit sur les pommettes, formant le dessin d'un papillon énorme avec les ailes étendues.

Les plantes des pieds sont calleuses, desséchées, couvertes de grosses écailles et excessivement crevassées dans toutes les directions. Ces crevasses sont très ardentes à certaines époques et quand il marche beaucoup, il se forme des phlyctènes qui, en se rompant, laissent le derme nu et très douloureux.

CARATÉ ROUGE.

Observation 16

Madame X..., O., âgée de 50 ans, de race blanche, native et résidant à Médellin où elle vit de ses rentes, dit avoir trois frères avec le caraté rouge généralisé et une sœur à peau complètement saine ; cette sœur a seulement 24 ans.

Il y a 20 ans, apparut chez elle une tache érythémateuse, fesonnée et en relief sur la partie postérieure de l'avant-bras droit ; la dite tache d'une couleur rouge-brique était abondamment couverte de petites écailles blanches et était dès le commencement très prurigineuse, cuisante et sèche par époques.

Aujourd'hui on voit sur l'avant-bras une tache lupiforme géante, qui couvre presque toute la partie inférieure du membre, inclus la face dorsale de la main.

Cette tache est serpigineuse et en relief, couverte de menues squames et est d'une couleur rouge-brique ou tuile.

Le reste de la peau est complètement sain, excepté les deux paumes des mains qui sont sèches et présentent une multitude de grosseurs calleuses, du volume d'une tête d'épingle ou d'une lentille ; les dites callosités se détachent de temps en temps en laissant une grande quantité de petits trous. La pression de ces clous cornés est douloureuse. Cette dame dit qu'à de certaines époques l'ardeur et la sécheresse des mains sont considérables.

Le prurit est presque permanent et produit un chatouillement très désagréable.

Observation 17

Madame X. V..., âgée de 40 ans, métisse, native et résidant à Médellin, où elle vit de ses rentes, dit n'avoir aucune personne de sa famille atteinte de caraté.

Il y a 15 ans, parut sur la partie inférieure du front une petite tache érythémateuse, desquamative et cuisante que tous les médecins, que l'on consulta, prirent et traitèrent pour un lupus érythémateux.

Aujourd'hui toute la figure, jusqu'au bord du cuir chevelu est couverte de taches rouges, peu saillantes et couvertes d'écailles larges, et minces. Ces taches sont séparées par d'étroites bandes de peau saine. Les plaques sont sèches et cuisantes. Les lèvres minces, desséchées et pleines de menues crevasses sont ardentes.

Tout le reste de la peau est normal et la chevelure abondante.

Notre première impression fut celle d'un lupus serpigineux, érythémateux ; mais vu sa résistance aux moyens classiques employés comme traitement, nous fîmes l'analyse microscopique et nous trouvâmes en abondance la moisissure du caraté rouge avec ses fruits caractéristiques ; alors nous le traitâmes avec la chrysarobine qui, en 15 jours, nettoya complètement toute la figure.

Observation 18

Juan J. R..., de peau blanche, natif de Concordia (climat froid), âgé de 27 ans, et muletier de profession, dit que son père, sa mère et une sœur ont le caraté rouge.

Il y a 7 ans, il lui sortit une tache rouge sur une cheville, ensuite sur le dos de la main droite et après sur la gauche.

Aspect externe. — Le dos des mains, le tiers inférieur des avant-bras, le dessus des pieds et le tiers inférieur des jambes présentent des taches rouge-brique ou rouge-violacé, dont quelques unes sèches, cartonnées, desquamatives et fissurées.

Les paumes des mains sont sèches et pleines d'un pointillé comme des têtes d'épingle, ces petits points cornés sont très sensibles à la moindre pression et très cuisants par époques.

Sur les plantes des pieds, la peau est sèche, d'une épaisseur considérable et croisée en tous sens par des fissures abondantes et profondes que le malade coud avec du fil pour éviter les cailloux qui, en marchant, s'y introduisent. Ces fissures saignent fréquemment et à certaines époques la marche est impossible à cause de la douleur.

Dans les parties couvertes du corps (région pectorale, bras), on voit des taches, livides, lisses et légèrement rougeâtres au centre ; ces taches ont de 5 à 10 centimètres d'extension ; elles ne le démangent ni ne le brûlent comme les autres.

Ce jeune homme fut traité par un empirique de renom et un mois après, il vient à la consultation où je pus vérifier la disparition des crevasses des pieds de même que l'hyperkératinisation de ceux-ci et des mains. Les taches rouges et violettes des avant-bras et des jambes avaient disparu laissant seulement la peau un peu écailleuse et grosse. Les plaques blanchâtres, dischromiques du tronc et des bras n'avaient pas changé. Comme le malade continua son métier, et à voyager à un port du fleuve Magdalena, quatre mois après les taches rouges des mains avaient reparu.

Observation 19

R. P..., âgé de 18 ans, de race blanche, étudiant, natif de Médellin.

Aucune personne dans sa famille ne présente de maladie de la peau ou du cuir chevelu.

Il dit n'avoir jamais eu la teigne ni d'autre maladie qui lui ait fait tomber les cheveux. Ce jeune homme alla au mois de janvier(1896)dans une ferme de terre chaude (bords du fleuve Cauca), et en revenant il remarqua une petite tache circulaire de la grosseur d'un franc sur le genou droit ; cette plaque était rouge, érythèmateuse et lui occasionnait un prurit léger.

Etat actuel. — Sur le genou droit une grande plaque rouge-pâle qui la recouvre en complet, est desquamative et limitée par un rebord net, saillant; la partie centrale présente une peau normale, excepté deux petites taches qui restent encore. Cette tache croît lentement et d'une manière excentrique, et tandis qu'elle gagne du terrain sur la périphérie, elle se guérit au centre.

Sur le bras droit, il présente une plaque circulaire, identique comme forme géométrique à la première ; cette plaque est aussi érythémateuse, bords en relief ; la peau centrale est normale, le prurit modéré et la desquamation légère ; cette tache apparut quatre mois après, et il l'attribue à une auto-inoculation pour s'être gratté le bras après s'être frotté la plaque du genou avec la main gauche.

Le monomorphisme et l'orbicularité, de même que leur petit nombre et, le fait qu'elles sont circonscrites aux parties couvertes, nous avaient fait penser à une trichophytie, de celles appelées exotiques ; mais l'examen microscopique, comme la culture des écailles, ne montrèrent aucun trichophyton, mais quelques myceliums et beaucoup de cellules en raquette. Vu ce fait, uni aux cultures qui donnent le champignon du caraté rouge, nous abandonnâmes tout doute sur la véritable origine de la maladie. Il s'agissait d'un caraté rouge trichophytoïde.

CARATÉ BLEU.

Observation 20

Pedro M. A..., blanc âgé de 24 ans, natif de Titiribi, journalier de profession, s'est occupé à de rudes travaux de campagne.

Ses parents et ses frères n'ont pas de caraté ; seulement un oncle présente l'espèce violette.

Dès l'âge de 3 ans commencèrent à se montrer des taches de caraté d'une couleur rougeâtre qui, peu après, devinrent bleues ; ces premières plaques lui sortirent sur le front, l'arête du nez et les pommettes ; cinq ans après, des taches bleues parurent sur le dos des mains, et ensuite des pieds.

Aujourd'hui, on voit des taches bleues, festonnées, sur la partie inférieure du front, les joues, le nez, la lèvre inférieure ; ces taches vont en se dégradant et se confondent insensiblement avec la peau normale. La partie du front qui est ordinairement à l'abri du soleil et couverte par le chapeau est complètement blanche et normale. Les avant-bras et les mains présentent plusieurs plaques bleues.

Dans la région pectorale, on remarque quelques taches bleu-violacé et d'autres petites et discrètes d'une couleur rosée, ou légèrement rougeâtre, entourées par une zone bleuâtre.

Il n'y a pas de prurit ni de desquamation, et la peau des taches de caraté n'est pas épaissie et présente l'aspect du tégument sain. Pas de crevasses palmo-plantaires.

CARATÉ NOIR D'ENCRE ET BLANC.

Observation 21

Suzana R..., négresse de 38 ans, native de la ville d'Antioquia et cuisinière de profession.

Ses parents et ses frères n'ont pas de caraté, une tante a le caraté blanc ; a souffert d'un rhumatisme et de fièvres paludéennes.

Elle réside à Médellin depuis son très jeune âge et là, quand elle était âgée de 20 ans, parut un petit bouton sur une jambe. Il démangeait beaucoup et alla s'étendant en formant des taches noires et blanches non consécutives, mais simultanées ; ces taches envahirent l'autre jambe et les bras ensuite, 4 ans après.

Aujourd'hui on voit sur les avant-bras quelques taches petites et noires comme de l'encre et d'autres blanc-rosé sur la partie antérieure, qui recouvrent tout le tiers inférieur et les paumes des mains. Le dos des mains présente une multitude de points blanc-rosé séparés par des îlots irréguliers de peau saine et de couleur normale. Les jambes et le dessus des pieds ont de grandes taches blanches, lisses, et quelques petites d'un noir d'encre, le tout séparé par des bandes minces et irrégulières de peau saine.

Les plaques blanches gardent une certaine symétrie et régularité de forme.

Ces taches ne sont pas desquamatives ni prurigineuses et l'épaisseur de la peau est normale et celle-ci est souple. Rien à remarquer sur les surfaces palmo-plantaires ni sur les muqueuses.

CARATÉ PSORIASIQUE.

Observation 22

Rafaël B..., blanc, natif de Médellin, âgé de 35 ans.

Parents et frères sans caraté ni autre maladie de la peau.

Trois ans après avoir travaillé dans une mine de Remedios, apparurent sur la jambe droite un grand nombre de petites phlyctènes qui le démangeaient beaucoup. Peu après des phlyctènes semblables se montrèrent sur d'autres points de la peau. Ces phlyctènes se séchaient et se recouvraient de quelques écailles blanches comme du papier de riz.

Autour de chaque papule squameuse sont apparus des cercles concentriques d'écailles de la même couleur jusqu'à former des plaques de dimensions variables, aux contours festonnés donnant origine, en s'unissant avec d'autres, à des figures circinées, giroïdales.

Aujourd'hui cette affection a deux ans d'existence et présente l'aspect suivant : sur la poitrine, des plaques géantes de contours géographiques, de couleur érythémateuse et desquamatives, entourées de peau saine. Ces taches sont nettement limitées de la peau normale par un rebord saillant. La desquamation est énorme, les écailles sont larges (jusqu'à un centimètre) et blanc-crème.

Le dos est complètement envahi, et il reste seulement des petits points de peau saine. Les membres supérieurs et inférieurs présentent les mêmes énormes taches pleines de larges écailles, d'aspect psoriasique.

Toutes ces macules sont prurigineuses et plus que tout cuisantes par époques.

Sur le dos des mains et des pieds les taches sont rouges, petites (pièce de 2 francs) et moins écailleuses. La nuque, le ront, les oreilles et les joues montrent diverses petites taches squameuses, sèches, circinées ; quelques-unes arrivent jusqu'au rebord du cuir chevelu, mais s'arrêtent sans affecter en rien les cheveux, que cet individu a abondants.

CARATÉ IMPÉTIGINEUX.

Observation 23

Lazaro C..., métis, âgé de 35 ans, natif de Barbosa et péon, dit que dans sa famille personne n'a de maladies de la peau.

Cet individu a une tuberculose pulmonaire depuis deux ans.

Il y a cinq ans apparurent chez lui de grandes pustules dans la région inter-scapulaire ; celles-ci se couvraient bientôt de grosses croûtes blanc-sale et étaient très prurigineuses. Aujourd'hui on voit des macules blanches cicatricielles, alternant avec de grosses croûtes ecthymateuses, giroïdes qu forment des figures circinées, et dont l'extension est excentrique, le centre se voyant couvert par des taches d'achromie regressive d'une régularité géométrique remarquable; le dos, les bras, le visage et la nuque sont pleins de ces croûtes impétigineuses.

Le prurit est grand quelquefois.

Le microscope montre une grande quantité de mycéliums pleins de fruits sporulés de caraté.

Observation 24

Ulpiana S..., mulâtresse de 26 ans, native de San Géronimo et servante de profession.

Elle a été paludéenne et rhumatisante. Aucun antécédent syphilitique personnel ni héréditaire.

Il y a trois ans parurent des petites vésicules pleines d'eau qui se convertissaient bientôt en pustules très prurigineuses et même douloureuses. De grosses croûtes se formaient et en tombant elles laissaient une tache achromique; mais pendant que le centre guérissait, autour apparaissaient d'autres petites vésicules qui suivaient le même cycle. Cette première éruption sortit sur la cuisse gauche, puis passa à l'autre et ensuite aux bras.

Aujourd'hui de grandes plaques ecthymateuses se voient, disposées en lignes serpigineuses circinées et de marche excentrique; ces zones concentriques présentent un centre couvert de macules achromiques, lisses, de la grandeur d'un franc.

Presque toute la superficie du tégument externe est affectée il reste seulement de petits îlots de peau saine et de couleur ɔrmale.

Le cuir chevelu présente aussi, sur quelques points, de grandes croûtes d'une couleur grisâtre, mais les cheveux ne sont pas tombés.

La malade dit qu'une de ses compagnes avait cette maladie et qu'elle l'a contagionnée.

Le microscope montre le mycélium du caraté avec nombre de fruits sporulés.

Vu : le président de la thèse
DIEULAFOY

Vu par le Doyen,
BROUARDEL

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GRÉARD

H. JOUVE, imprimeur de la Faculté de médecine, 15, rue Racine, Paris.

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Bacteriologic and Pathologic Evidences in Past Geologic Ages

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BACTERIOLOGIC AND PATHOLOGIC EVIDENCES IN PAST GEOLOGIC AGES

ROY L. MOODIE
(From the Department of Anatomy, University of Illinois, Chicago)

In the literature of vertebrate paleontology there are a number of incidental references to the diseased nature of the fossilized bones of fishes, reptiles, birds and mammals. The lesions represented in a fossil condition show a variety of diseases which are common today, indicating the great antiquity of disease. It is manifestly impossible to correctly diagnose, on the basis of our knowledge of modern diseases, the lesions which are preserved to us in a fossil condition. In the extinction of the ancient races of animals certain diseases without doubt became extinct with them, and it is partly the purpose of this study to inaugurate an inquiry into the nature of ancient diseases. No attempt has yet been made to study carefully all of the evidences of disease among ancient animals since these conditions, whenever noted, have been referred to only in an incidental way. It is no doubt true that the general processes of pathologic conditions will be found to be the same or at least similar in ancient geologic times and at the present time. Our studies to date indicate this clearly. We wish also to point out that some of the diseased conditions to which man is today an heir may have originated back in the Paleozoic and the human race has inherited some of its troubles at least from the fishes and reptiles which lived many millions of years ago.

The diseases which have been cited among the fossil vertebrates are:

1. Caries, which is very common among fossil vertebrates and has been described by Renault[1] as occurring among Permian fishes 25,000,000 years ago. A large marine reptile, one of the Cretaceous mosasaurs, shows in the left mandibular ramus extensive evidences of the ravages of this disease. In an early Tertiary species of the three-toed horse the mandible has been affected by caries and possibly also by *actinomycosis,* as well as by *pyorrhea.* Caries has been noted in the jaw of a mastodon, and in the early cave bears of Europe.

2. Pyorrhea is especially evident in the absorbed alveolar margins and in the loosened teeth of a three-toed horse from the Miocene of North America and is also otherwise indicated in the cave bears.

3. Deforming arthritides are fairly common among fossil vertebrates and indicate a variety of pathologic conditions. The most prominent case of a deformed joint is the case of two caudal vertebrae of a large dinosaur, the interarticular surfaces of which have been extensively deformed and surrounded by huge exostosial growth. The enlargement is somewhat suggestive of the lesion of chronic osteomyelitis. It may be a callous growth possibly due to a fracture of the caudal vertebrae, or it may be a bone tumor. The mass resembles the tumor-like masses of oak trees. It entirely encircles the vertebrae and has involved fully half of the two bones. All evidences of separate structures are obliterated, and the two vertebrae are fused into a single mass. The specimen has a length of 26.5 cm. and a weight of 5.1 kg. The circumference of the normal articular surface of one of the vertebrae measures 27 cm., and the same measurement around the middle of the tumor-like mass is 38.5 cm. The lesion has involved a length of 12 cm. Its surface is generally rather deeply pitted. There is an unusual ventral growth, which has carried with it the chevron, the bony process which served to protect the caudal vein and artery.

The condition sometimes spoken of as ***rheumatoid***

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[1] Renault, B., 1899-1900. Sur quelques Microorganismes des combustibles fossiles. Bulletin de la Société de l'Industrie minerale Saint-Étienne, Tomes 13-14, with folio atlas of 20 plates of untouched photomicrographs.

arthritis has been noted in the cave bears, in certain fossil human skeletons, in the famous Lansing man[2] of Kansas, and it is probably indicated in the Cretaceous mosasaurs.

A similar indication but of more extensive growth is evident in the cave bears of the Pleistocene of Europe which have been studied especially by Rudolf Virchow. Deforming arthritides are said to be quite common in fossorial mammals.

4. Osteomyelitis is indicated in the dinosaurian caudals described above, and in certain phalangeal elements from the Pleistocene of California.

5. Exostoses due to trauma, indicated as callous growths around fractures of ribs and limb bones, or as outgrowths due to chronic irritation or infection may be said to be fairly common. Broken and healed fractures are very common among mammals and are occasionally seen among fossil reptiles. Dinosaurs exhibiting broken ribs, vertebrae, horn cores, etc., attest the accidents or fights which caused these traumatic conditions and has led Abel[3] to infer that the males of these animals contested during the breeding season for the female. An exostosis which is especially clearly marked is evident on the inner or visceral surface of a dinosaur scapula where it takes the form of a hook-like process evidently due to chronic irritation. One of the most perfect indications of exostoses is seen in a mosasaur from the Cretaceous of Kansas where there is a decided lump at the articular surface between the third and fourth dorsal vertebrae.

6. Periostitis or some similar condition is evidently the cause of the production of exostosial growths in the humerus of a Cretaceous mosasaur from Kansas. It is also abundantly indicated in the limb bones of the *Soltaire,* an extinct quaternary bird allied to the dodo found on the island of Rodriguez, off the coast of Madagascar.

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2. Parker, Charles A., 1904. Evidences of Rheumatoid Arthritis in the Lansing Man, Amer. Geol., Vol. xxxiii, pp. 39-42.

3. Abel, O., 1912. Grundzüge der Palaeobiologie der Wirbelthiere, p. 95.

7. Osteosarcomata have not been positively identified among extinct animals but the condition is suggested in several instances.

8. Fistulae are evident in the lower jaw of an ancient and primitive whale from the Eocene of Egypt[3] and an enlargement of the mandible of a three-toed horse from the Miocene of North America indicates the presence of a fistula, possibly due to *actinomycosis,* in its early stages.

9. Rickets is indicated among the apes which are found mummified in the old Egyptian graves.

10. Necroses, due possibly to a variety of causes, and attributed by certain French writers to tuberculosis, are fairly common among fossil vertebrates. A marked necrosis of the ilium of a large dinosaur, accompanied by expansion and thickening of the bone, is evident in the mounted skeleton of *Camptosaurus*[4] on exhibition at the National Museum in Washington. A mosasaur bone from the Cretaceous of Kansas and certain crocodile limb bones from the Jurassic of England show lesions of necrotic nature. The assignment of any of the lesions to a definite cause is manifestly impossible, and while tuberculosis has been suggested as a possible cause the diagnosis is so uncertain as to be nearly worthless.

11. Hyperostosis or *pachyostosis,* which is similar to the enlargement of the bones in Cretanism, and is indicated as a thickened and enlarged part of the skeleton, has been detected in fishes and reptiles, some of them of great geologic antiquity.

The study of Palaeopathology is just begun and what the results may be remains to be seen. It is, however, certainly of very great interest to find in past geologic ages, lesions which are so familiar to us today. If we can trace the lesions known to any definite cause among extinct animals, it will be a step toward the erection of the newest branches of pathology and dealing with the oldest aspects of that science.

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[4] Gilmore, Charles W., 1912. The Mounted Skeletons of Camptosaurus in the United States National Museum, Proc. U. S. Natl. Mus., Vol. 41, p. 689; pls. 56 and 58.

Our knowledge of the bacteriology of past geologic ages is due largely to the researches of Renault[1] and his associates in France. The nature of many of the lesions seen in fossil bones likewise indicates or suggests the presence of bacteria. Renault described and figured many primitive forms of bacteria and fungi from the late Paleozoic and early Mesozoic rocks of many countries. He found these forms especially abundant in the fossilized feces (coprolites) of fishes, in ancient wood, and in coal. He also discovered in the teeth of certain extinct fishes indications of *caries*, as shown by the irregular decayed spots within the substance of the teeth. He shows in one of his plates some photomicrographs of fossil bone from the petrified feces in which the ravages of the bacteria are evident in the enlarged and distorted canaliculi and bone corpuscles.

Renault's work is the summing up of twenty-four years' activity during which time he investigated the nature of the micro-organisms in the following materials: (1) Peat, the age of which may be either a few years or many thousands of years. (2) Lignite or brown coal. (3) Recent bituminous schists in which he found rhizopods, bacteria and fungi. (4) Boghead coal. (5) Canal coal. (6) Ancient bituminous schists and (7) Silification of organisms in very ancient rocks. Evidences of bacterial activity are also found in the so-called ichthyodorulithes or fragments of bone which are found isolated in the rocks.

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PALEONTOLOGICAL EVIDENCES OF THE ANTIQUITY OF DISEASE

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By Professor **ROY L. MOODIE**

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PALEONTOLOGICAL EVIDENCES OF THE ANTIQUITY OF DISEASE

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PATHOLOGICAL conditions among fossil animals are known as far back in geological time as the Carboniferous, hence it may be proper to state on the basis of our present knowledge that disease began, among both plants and animals, during the great Coal Period. These evidences are found both in the new and the old world, so that there must have been a very fundamental condition underlying the evolution and development of animal and plant races which favored the ingress of disease and the overpowering of the natural immunity which had previously protected the forms of life from the devastations of disease. This statement of affairs implies the absence of disease, or of a tendency toward disease, among the inhabitants of the earth during the geological periods prior to the Mississippian. This may not be correct, but so far as we know at present the animals of the Paleozoic and Proterozoic were free from disease. The factors which have been important in the origin of disease have been discussed by the writer[1] in an essay which had in view an outline of the entire subject of the origin and development of disease as seen in the lesions on fossil bones. A study of senescence in dogs and the relation of old age to disease recently made by Goodpasture[2] supports in an interesting manner a suggestion made by the writer[1] concerning certain factors in the origin of disease among the animals of past ages.

CARBONIFEROUS

Present evidences tend to show that the Coal Measures witnessed the origin of disease. The oldest known evidences of pathological conditions among fossil animals are to be found in the enlarged stems of fossil crinoids, which have been known for many years. They were described by Robert Etheridge, thirty-eight years ago, from the Carboniferous of Scotland. Five years later a correct interpretation of these deformities was given by L. von Graff. He showed, on the basis of similar

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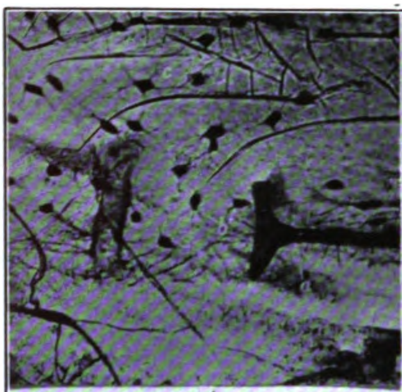
[1] "Studies in Paleopathology. I., General Consideration of the Pathological Conditions found among Fossil Animals," Annals of Medical History, Vol. 1, No. 4, 1918.

[2] "An Anatomical Study of Senescence in Dogs, with especial Reference to the Relation of Cellular Changes of Age to Tumors," *Journ. Med. Research*, Vol. XXXVIII., No. 2, pp. 127–190, 1918.



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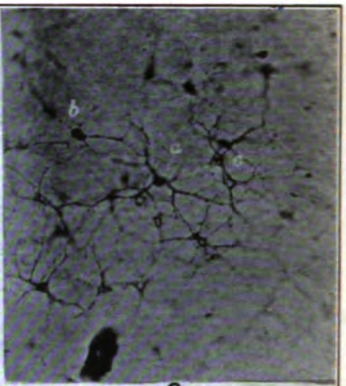

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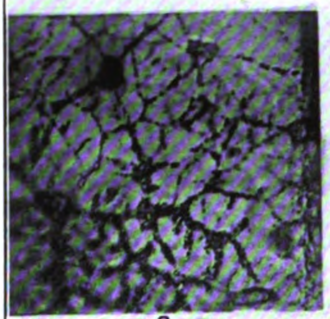

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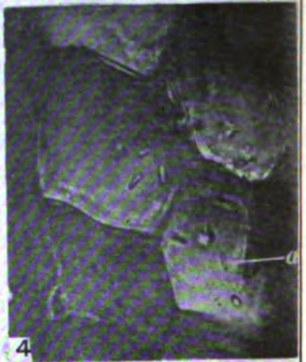

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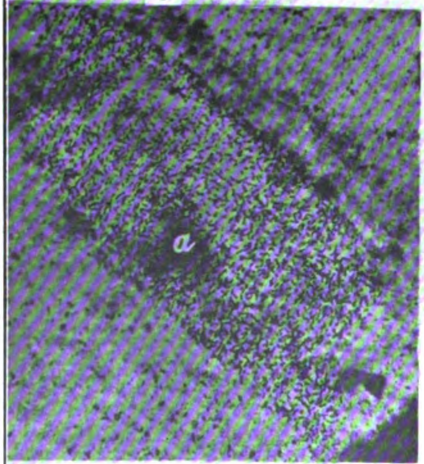

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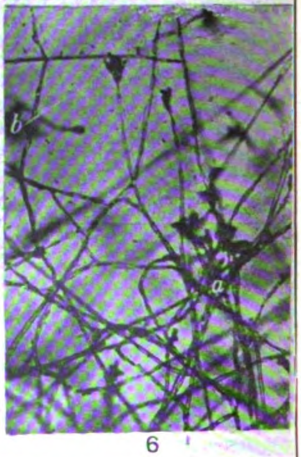

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Fig. 1. Photomicrograph of a Fragment of Fish Bone from the Autun Basin of France, showing the nature of the osseous lacunae, canaliculi and vascular channels.

Fig. 2. Photomicrograph of another Portion of the same Bone showing in the enlarged canaliculi and lacunae the ravages of micrococci which have invaded the channels and have begun the destruction of the bone.

Fig. 3. Photomicrograph of another Portion of the same Bone showing a further stage of destruction. The form of the lacunae and canaliculi are barely perceptible, since they are packed full of colonies of micrococci.

Fig. 4. Scattered Bacteria in fossilized Plant Cells, one of them at *a* showing faint indications of a mucoid capsule.

enlargements among recent crinoid stems, as described and figured in the Reports of the Challenger Exploring Expedition, that these enlargements were due to the parasitic action of myzostomids. Graff supported his interpretation by describing the carbonized remains of some worm, supposedly one of the myzostomids, to which the tumor was due, preserved in a channel of one of the fossil lesions. Similar objects are common from the Carboniferous of North America and doubtless they have a very wide distribution.

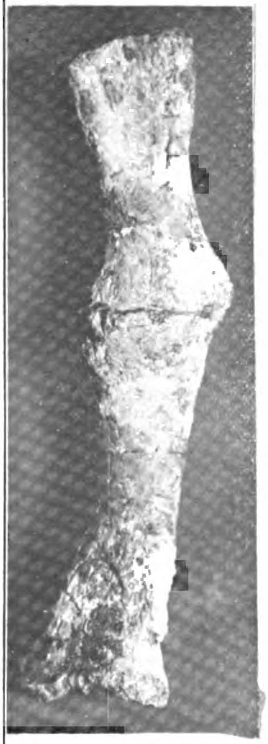
During the Carboniferous also there was a widespread development of fungi and bacteria which doubtless were influential in the spread of disease. Renault has found these forms abundantly preserved in the fossilized feces of fishes, in ancient wood and in coal. He also discovered in the teeth of certain extinct fishes indications of caries, as shown by the irregular decayed spots within the substance of the teeth. Renault's work covered many geological periods later than the Coal Measures, and his large monograph is the summing up of twenty-four years of activity spent in investigating the nature of the "Microorganismes des combustibles fossiles" in peat, lignite, bituminous schists (in which he found rhizopods, bacteria and fungi), boghead coal, cannel, ancient schists and the silicification of organisms in very ancient rocks. Renault's work is of great importance. A few of his figures are given herewith (Figs. 1–6). The bacteria take the form of coccoids, bacilli, diplococcoids and micrococcoids. Often in sporangia of the early cryptogamous plants Renault found natural cultures (Fig. 5) of bacteria which have been preserved by silicification. These organisms, which have been made so well known by the studies of French scholars, may all of them have been non-pathogenic forms, but the possibility of their being the cause of the disease of succeeding forms of life is very evident, and they should be mentioned as possible sources of disease.

PERMIAN

The great Permian period, with its widespread development of curious reptilian forms, has furnished us with the first evidences of traumatic conditions as they prevailed among the early forms of life. Fractures may have occurred earlier than the Permian, but they have not yet been seen. The oldest known fractures are found among the reptiles from the Permian of Texas. A left radius of *Dimetrodon*, a primitive reptile, pre-

FIG. 5. SILICIFICATION OF A NATURAL CULTURE OF BACTERIA FROM THE PERMIAN.

FIG. 6. MYCELIA AND SPORANGIA OF FOSSIL FUNGI as seen under high magnification in a thin section of fossil wood. Favorite places for the growth of bacteria. All figures taken from Renault's monograph "Microorganismes des combustibles fossiles."



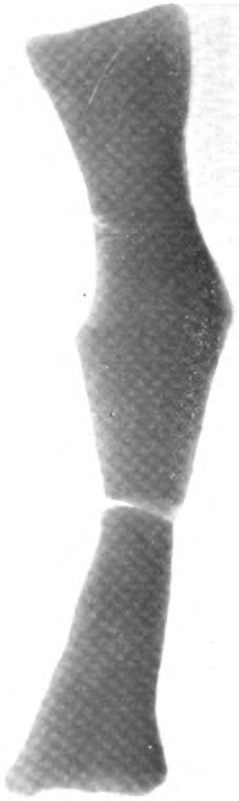


FIG. 7. LEFT RADIUS OF *Dimetrodon*, a primitive reptile from the Permian of Texas, showing, in the enlarged portion of the bone above, a simple fracture and considerable callus with some intermediary callus. Specimen the property of the Walker Museum University of Chicago. Loaned for study and description by Dr. S. W. Williston.

FIG. 8. X-RAY PICTURE OF THE BONE. The fracture lines above and below the callus are post-fossilization fractures and have no significance.

sents a well-marked case of fracture (Fig. 7) with subsequent healing, although there is still some intermediary callus. An attempt to study the nature of this fracture by means of the X-ray has not resulted in any new knowledge, but it may be interesting to present the attempt (Fig. 8). The fracture runs directly across the bone, as do all the early cases of fracture among animals with solid limb bones, and the resulting callus has produced a decided enlargement of the bone around the fracture. The fractures seen in the X-ray picture above and below the callus were produced after fossilization and have no significance.

A small fragment of a fractured rib from the same beds, in which there was quite an old callus, has been studied microscopically (Fig. 9). The callus was quite evidently an old one, for the fracture was completely healed. A study of the microscopic section proves this to be true, since evidences of osteosclerosis and osteohypertrophy are clearly evident. The region of the figure to the left of the spicule of bone is regarded as due to osteosclerosis, which is interpreted on the basis of the presence of a heavy deposit of calcium salts and the absence of osseous trabeculae. The white band running vertically may be interpreted as a spicule of bone due to the splitting of the rib. Its bony nature is definitely established by the presence of lacunae, and its presence in this position is due to the ingrowth of new bone along a cleft produced by the splitting of the rib. The hypertrophied area to the right of the osseous band is often seen in old calluses and is interpreted on the basis of the presence of numerous trabeculae of bone. There is no evidence that the fracture was infected, necrotic sinuses being entirely wanting.

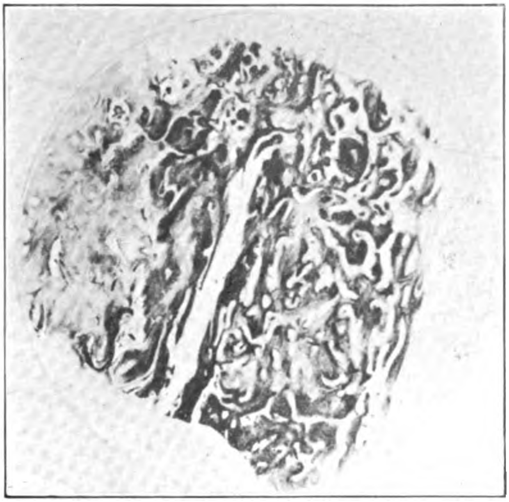


FIG. 9. MICROSCOPIC STUDY OF THE DETAILS OF A FRACTURE IN A RIB OF A REPTILE FROM THE PERMIAN OF TEXAS. The white spicule running vertically in the figure is the ingrowth of bone into a split portion of the rib. On the left of this spicule is to be seen the osteosclerotic portion of the old callus, indicated by a heavy unorganized deposit of calcium carbonate or some similar salt. On the right is seen the hypertrophied area, identified by the heavy deposition of bone with small lacunae and canaliculi. The lacunae have largely disappeared in reproduction but are clearly evident on microscopic examination of the bone.

TRIASSIC

Except for occasional specimens of fossil fishes and other forms preserved in the pleurothotonos and opisthotonos (Fig. 10A), attitudes suggesting a condition of spastic distress,[3] little is known about the pathology (Fig. 10B) of the animals which

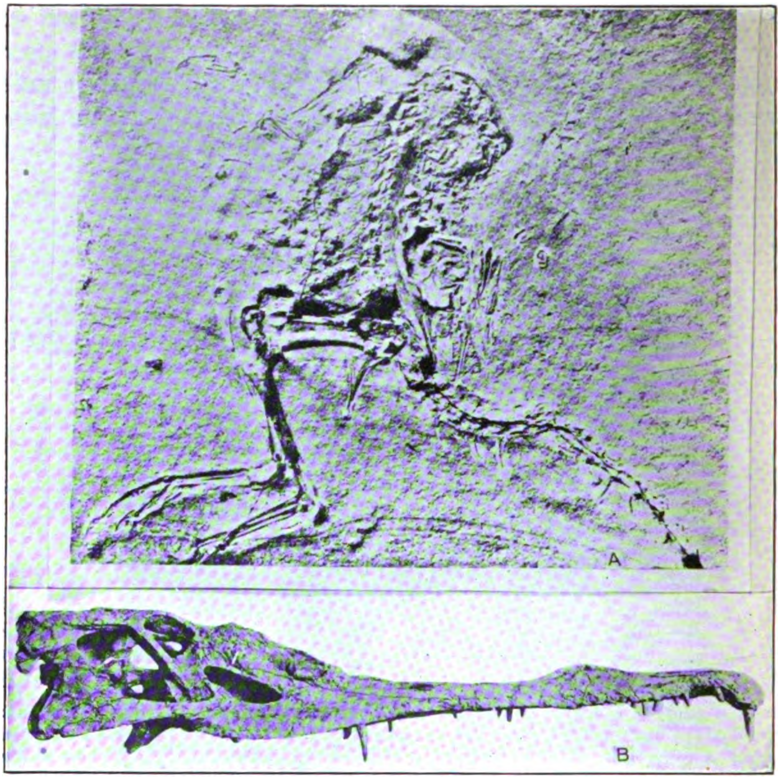


FIG. 10*A*. THE SKELETON OF *Compsognathus longipes,* a small Triassic dinosaur, fossilized in the position of opisthotonos, a position which has been suggested as an evidence of cerebrospinal infection. The head is thrown far back over the pelvis and tail thrown sharply up with the feet and limbs in a spastic attitude.

FIG. 10*B*. THE SKULL OF *Mystriosuchus Plieningeri* H. von Meyer, a parasuchian, from the Triassic of Aixheim, exhibiting a broken snout (above letter *B*) with resulting callus and bone necrosis. After Huene.

lived during the Triassic. There doubtless is much to learn in the future, since many vertebrate species are known from this period.

JURASSIC

The Jurassic of England furnishes us the first evidences of necrosis and a suggestion of metastasis as seen in the pathological nature of the bones of *Metriorhynchus moreli* Desl., a crocodile described by Erwin Auer[4] from the Oxford Clay.

The skeleton of this interesting animal was only partially preserved. There are evidences of pathology in the palate, on the two femora, on a sacral vertebra and on the pelvis. Auer says:

---

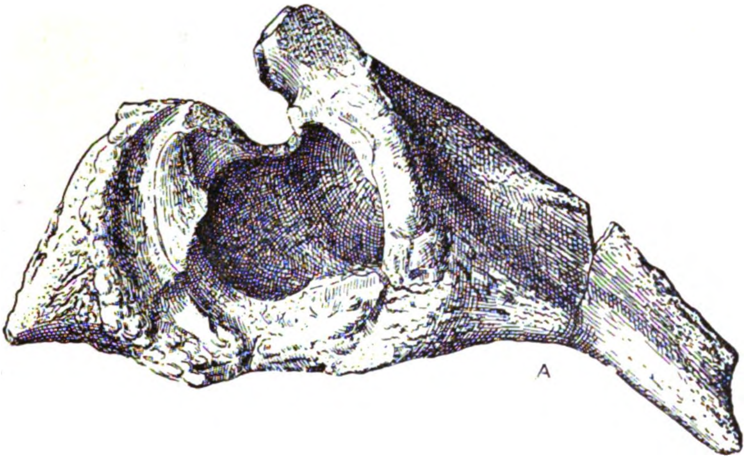
[3] "Studies in Paleopathology. III., Opisthotonos and allied Phenomena among fossil Vertebrates," *American Naturalist,* Vol. LI., No. 617-618, 1918.

[4] *Paleontographica,* Bd. 55, pp. 277, 279–280, figs. 13–14.

On the middle of the inferior side of the palatine is a section that is unusually differentiated by cavities, and consists of fossulae, a condition that is not otherwise encountered in crocodiles, and that doubtless is connected with the pathogenic deformities the bones exhibit.

The right femur is normally formed, but it displays below the caput femoris a peculiar corrosion, and the condylus internus is reduced at the distal end.

The left femur (Fig. 11*a*) departs in form quite considerably from the normal type. The head of the bone has undergone a significant contraction, and the formerly globular articular surface is deformed. Under the head of the bone the femur exhibits an abnormally small diameter, and on the external side of the bone a ridge is raised.



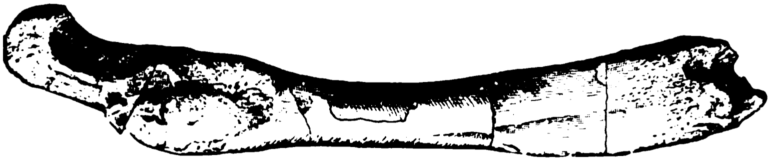


Fig. 11*A*. Sacral Vertebra of *Metriorhynchus moreli* Desl. from the Oxford Clay of England, showing carious roughening and necrosis. After Auer.

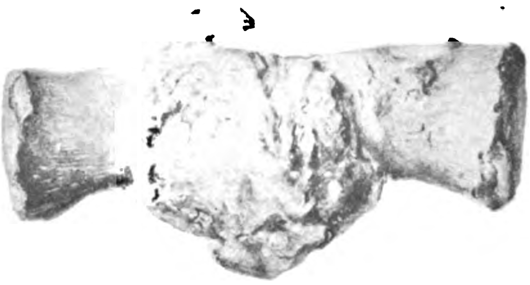
Fig. 11*B*. Left Femur of the same, showing pathological roughening at the upper and lower extremities, especially around the trochanetric region. After Auer.

The sacral vertebra (Fig. 11*b*) also exhibits significant deformities of a pathogenic nature; the body of the vertebra is noticeably thickened, irregularly jagged on the outer side and set with numerous rather deep holes. The body of the vertebra is completely hollowed out from the end surface.

The description indicates the presence of a tuberculous or similar necrosis of the bones and is the most complete example of a seriously diseased vertebrate which has been seen in the fossil condition.

COMANCHIAN

The gigantic dinosaurs of the Comanchian have long been known to have suffered from disease and injury and the writer



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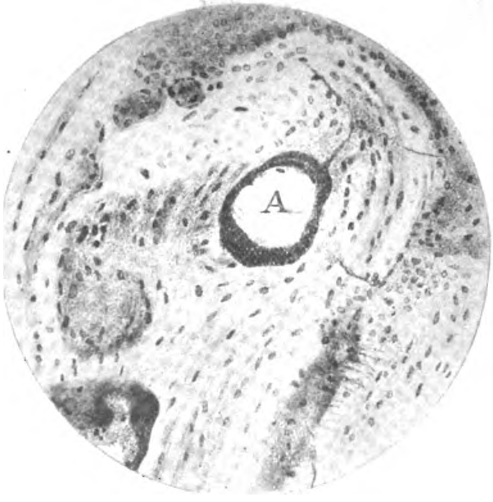

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Fig. 12. Deformed Joint between two caudal Vertebrae of a Dinosaur (*Apatosaurus*) caused by the growth of a tumor-mass, which on account of its extreme vascularity represents possibly an haemangioma, or some similar pathological growth.

Fig. 13. Microscopic Section of a Portion of the Periphery of above Tumor, showing arrangement of lacunae, vascular spaces (*a*) and lamellae of bone. How much this differs in arrangement of elements from normal bone remains to be determined.

has described these sufficiently in other places[5] to make their characters well known. The most interesting lesion seen among the dinosaurs has been regarded as resembling a modern hemangioma (Figs. 12–13). Fig. 14 will show the nature of the vascular spaces and the arrangement of the osseous trabeculae as seen in a sagittal section of the tumor mass.

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[5] "Pathologic Lesions among Extinct Animals: A Study of the Evidences of Disease Millions of Years Ago," *Surgical Clinics of Chicago,* Vol. 2, No. 2, pp. 319–331, Figs. 108–116, 1918.

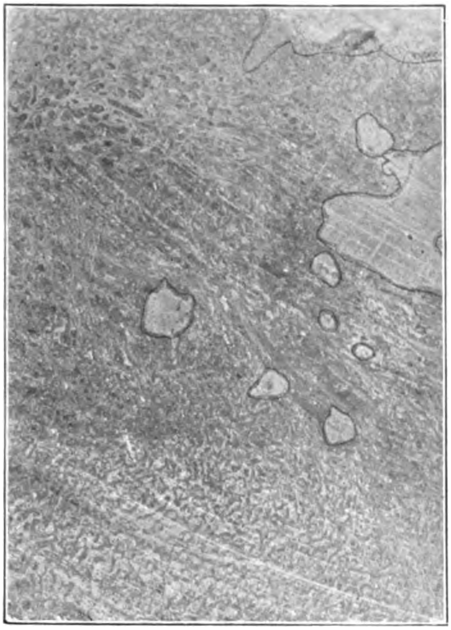

FIG. 14. PHOTOGRAPH, ENLARGED, OF THE CUT SURFACE OF THE TUMOR SHOWN IN FIG. 12, to show the arrangement of the trabeculae of bone and the large vascular spaces (areas outlined in ink). The large area at the top of the figure is apparently a portion of the intravertebral space, which has become largely obliterated by the growth of the tumor. The substance of the chevron, seen in Fig. 12 as portion of the tumor, has been incorporated, when seen in section, with the mass of pathological bone.

CRETACEOUS

The diseases of the mosasaurs may be taken as a sample of the prevalence of disease and injury among the vertebrates of the Cretaceous. These aquatic vertebrates, as well as their congeners, the plesiosaurs and dinosaurs, were afflicted with a variety of diseases and the writer has been able to study the details of the lesions on the fossils from the Cretaceous of Kansas. Twenty years age Doctor Williston called attention to the diseased nature of the arm bones of one of the Cretaceous mosasaurs. Recently I have been able to study these bones (Fig. 15). Their pathological nature and the exostoses of a hyperplastic nature are at once evident (Fig. 15). A tentative diagnosis of osteoperiostitis has been given as the cause of the lesions. Microscopic study of the lesions (Figs. 16 and 17) reveals the bony lamellae laid down in a concentric manner, as if to form Haversian systems. The lacunae are relatively large

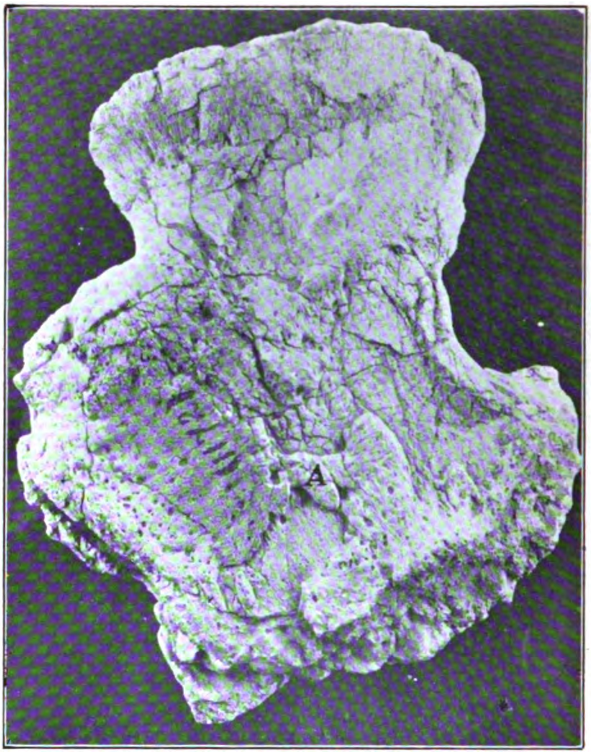

FIG. 15. HUMERUS OF A MOSASAUR, *Platecarpus coryphaeus*, from the Niobrara of Kansas showing the details of pathological lesions resembling those seen in modern osteoperiostitis. The microscopic sections (Figs. 16–17) were taken from the lesion at *A*. The disturbance also involved the articular surfaces indicating the presence of an arthritic infection.

and are provided with short canaliculi, and there are areas where osteoid tissue (Fig. 16) is present, comparable in every way with osteoid tissue, seen in modern cases of osteomyelitis. For the first time in the history of paleohistology perforating fibers of Sharpey (Fig. 17) are seen running through the sections.

A dorsal vertebra of *Platecarpus*, a well-known mosasaur from the Cretaceous of Kansas, presents an extremely interesting example of an osteoma (Fig. 18), the only one thus far known in a fossil condition. The specimen has not yet been studied microscopically, but a gross examination of a sawn section (Fig. 19) through the osteoma and vertebra shows in a very interesting manner how the tumor mass grew out of the vertebra. An X-ray examination of the bone reveals nothing of importance.

A radius of another mosasaur shows on the proximal surface an extensive necrosis. Sections of the bone show hyper-

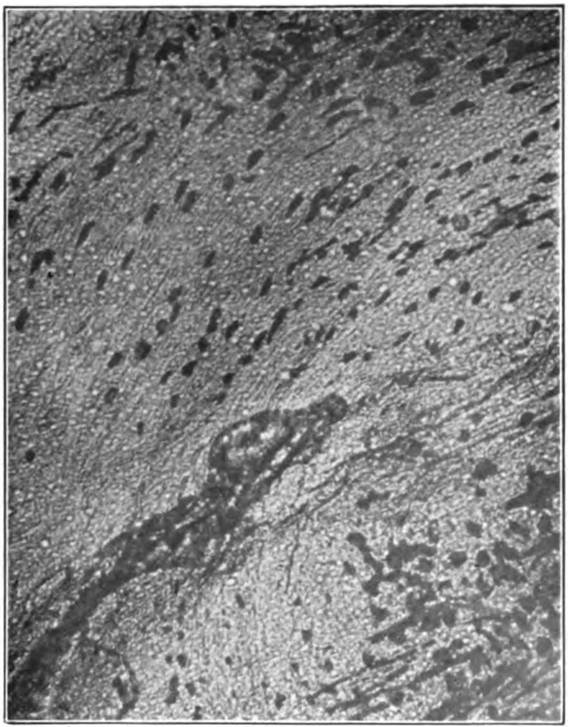

FIG. 16. PHOTOMICROGRAPH OF THE PORTION OF THE LESION (*A*, Fig. 15), showing osteoid tissue. The black lacunae are seen to be without canaliculi and their arrangement in concentric lamellae suggests the presence of an Haversian system. The dark area running obliquely out of the lower left hand corner is a post fossilization fracture filled with calcite. This area of osteoid tissue in the humerus of a mosasaur, 15,000,000 years old, is identical in anatomical structure with osteoid tissue from the human humerus in a case of osteomyelitis.

trophy of the peripheral substance. The nature of the organism producing the necrosis is not determined, but the fossil presents an exact duplicate of modern instances of extensive arthritic necrotic sinuses, which result in hypertrophy and the production of numerous osteophytes.

Dollo has described dental caries in a mosasaur jaw, with a hyperplasia of the bone with accompanying necrosis, as if the creature had suffered from a mouth infection similar to modern alveolar pyorrhea. The results are identical in modern and ancient bones.

The prevalence of disease reached a climax in the mosasaurs, dinosaurs, plesiosaurs and turtles of the Cretaceous, and with the opening of the Tertiary the incidence of disease went sharply down, to rise again with the rise of mammalian life and reach a very high point during the Pleistocene.

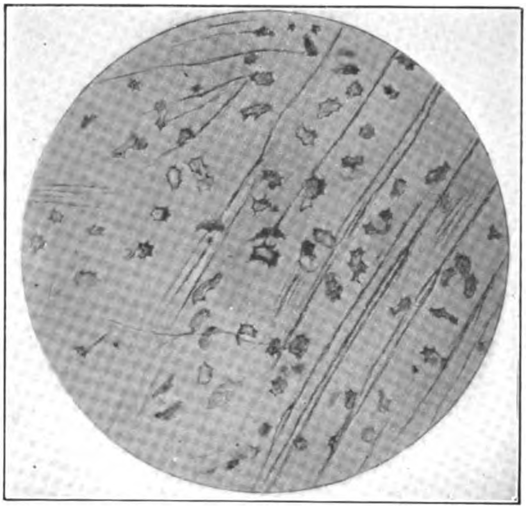

FIG. 17. MICROSCOPIC STUDY OF ANOTHER AREA OF THE SAME SECTION AS THAT SHOWN IN FIG. 16, showing the presence of perforating fibers of Sharpey, the long black fibers running obliquely through the figure, and small lacunae with short canaliculi, without any definite arrangement into systems.

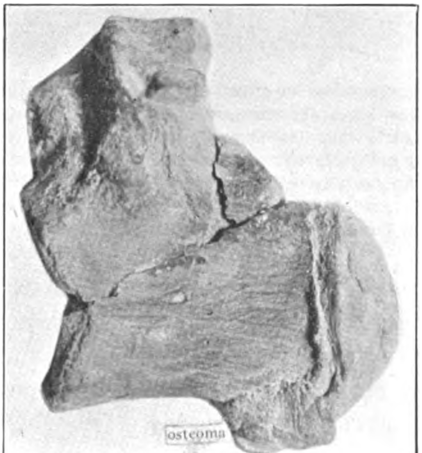

FIG. 18. A DORSAL VERTEBRA OF A MOSASAUR, *Platecarpus*, from the Niobrara of Kansas, showing on the posterior (right hand of figure) end of the vertebra an osteoma, the only known fossil representative of this type of tumor.

EOCENE

The extinction of the large groups of reptiles at the close of the Cretaceous doubtless brought about the disappearance also of many forms of disease which attacked these animals. Some forms of disease, as seen in the lesions left on the fossil

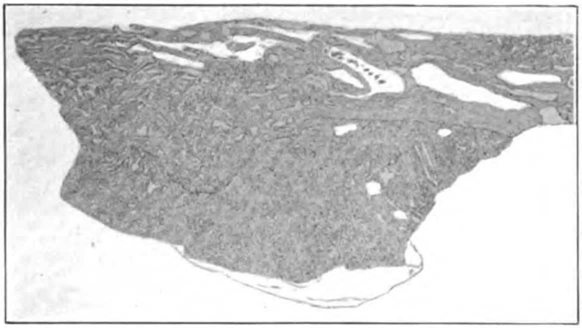

FIG. 19. A DRAWING OF A SAWN SECTION OF THE VERTEBRA, at the region of the occurrence of the osteoma, showing how the pathological structure grew out of the body of the vertebra.

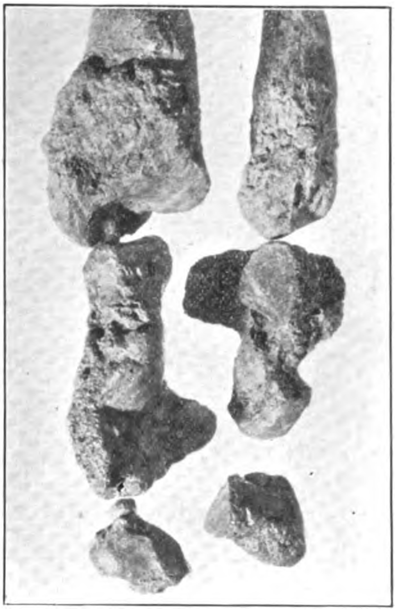

FIG. 20. TIBIA AND FIBULA WITH TARSAL BONES OF *Limnocyon potens*, a carnivore from the Washakie Eocene, showing in the carious roughening and hyperostoses evidences of disease resembling the results of osteomalacia of today. Published through courtesy of Dr. W. D. Matthew.

bones, were persistent as may be seen in cases of caries and alveolar osteitis with the associated forms of necrosis. It is to be expected that the paleontological evidences of disease would be rather scanty during the Eocene and in fact not a great deal is known. One interesting indication of a pathological condition may be seen in the tibia, fibula and associated tarsal bones of *Limnocyon potens*, a creodont carnivore from the

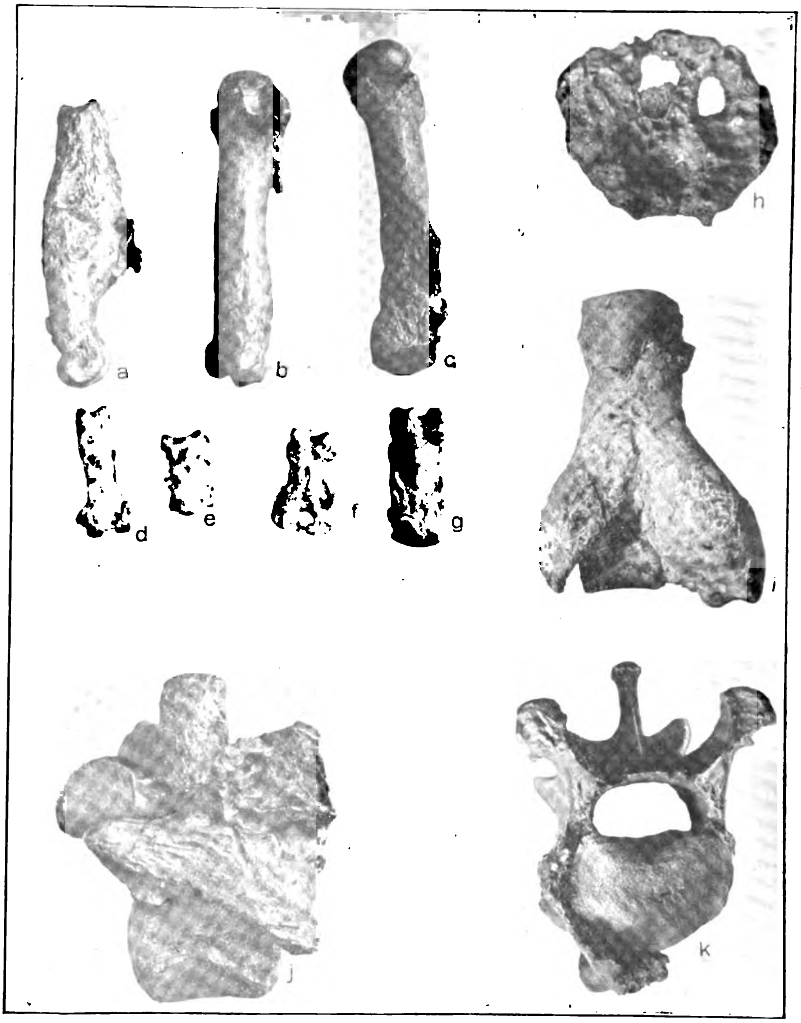

FIG. 21. *a*, metatarsal of a giant wolf, *Canis dirus*, from the Pleistocene, Rancho la Brea beds, of southern California showing a fracture of the middle of the bone with repair and the ensuing callus and exostoses. *b*, metatarsal of a saber-toothed cat, *Smilodon*, from the same deposits, showing on the upper right-hand surface a sharp exostosis, doubtless due to the infection of a tendon sheath, or some similar irritation. *c*, another metatarsal of a saber toothed cat from the same beds, showing on the lower end of the bone considerable carious roughening and hyperostosis. *d, e, g*, phalanges of a giant wolf showing slight exostoses due to some infection. *f*, phalange of a wolf. In the lower end the erosions of chronic osteomyelitis (?) or some similar long standing necrosis, produced by infection. An end view of this phalange, enlarged, is shown in *h*. *h*, end view of phalange (enlarged) shown in *f*, giving a clear idea of the necrosis produced by the infection. *i*, a pathologic camel phalanx from the Rock Creek beds (Pliocene or early Pleistocene) of Texas. This specimen has been discussed by Troxel (*Amer. Journ. Sci.*, XXXIX., p. 626, 1915) where he says: "Possibly the disease which caused the death of the individual also contributed to the destruction of the species." A supposition which is not supported by the evidence, since the pathological condition as seen in this single phalanx would have caused merely a stiffness and consequent lameness of the foot. Photo published by courtesy of Dr. R. S. Lull. *j*, vertebra of a saber toothed tiger from the Rancho la Brea beds of southern California, showing necrosis in the process seen on

Washakie Eocene. These bones (Fig. 20) show considerable exostoses and hypertrophy indicating an infection of some duration. The appearance of the bones suggests modern conditions of nutritional disturbances resulting in the softening and lightening of the bones as in osteomalacia.

OLIGOCENE

The mammals of the Oligocene suffered from disease and injury, though not so greatly as their successors, nor were any of the diseases prevalent at that time of sufficient importance to produce extinction. It must be remembered, however, that paleontological evidences of the antiquity of disease deal with hard parts exclusively, the soft parts known not being pathologic. The Oligocene dog, *Daphænus felinus*, so carefully and beautifully described and figured by Hatcher[6] presents on the inferior portion of both radii a symmetrical tumor-like mass, the only example of duplicate exostoses in fossil animals. The nature of the exostosis is problematical and I have not been able to find a parallel for this condition among the lesions on human bones. An excellent example of fracture with resulting callus formation and a splendid pseudarthrosis is known in a rib of the right side of *Titanotherium robustum* a perissodactyl from the White River beds of South Dakota, described by Osborn.[7] A careful account of this interesting fracture has been given by the writer,[8] accompanied by a detailed illustration of the callus.

MIOCENE

As an example of the nature of disease during the Miocene may be mentioned the nature of the lower jaw of the type skeleton of *Merychippus campestris*, a three-toed horse from the Loup Fork beds of South Dakota. One ramus of the jaw has a prominent swelling indicating the presence of a long-standing infection possibly of actinomycosis in its early stages, before the eruption of the bone took place. Alveolar osteitis with the

the upper right hand spine. *k*, end view of vertebra of saber tooth from the same beds, showing on the ventral surface of the body of the vertebra pathologic lesions of *spondylitis deformans*. Doubtless a series of vertebrae were ankylosed by the lesion, since the part shown is broken square across. Lesions of spondylitis deformans are fairly common in the mammalian remains of the Pleistocene.

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[6] "Oligocene Canidæ," *Mem. Carnegie Museum*, Vol. 1, no. 2, p. 85, pl. XIX., figs. 9 and 11.

[7] *Bull. Amer. Mus. Natl. Hist.*, Vol. VII., p. 347, 1895.

[8] *Annals of Medical History*, Vol. I, No. 4, 1918.

formation of some osteophytes, resembling the results of pyorrhea are also seen, and one molar tooth is afflicted with caries, a common occurrence among fossil animals.

PLIOCENE, PLEISTOCENE AND RECENT

The pathological conditions found among the mammals of the Pliocene, Pleistocene and Recent geological periods were the first known and have been extensively described and studied by a number of writers from Esper (1774) to Virchow (1895). There are about twenty contributions dealing with the diseased nature of bones from these periods. A review of our knowledge, especially of the pathology of fossil man, has been given elsewhere[9] and little need be said here concerning the pathological evidences from these periods. A few examples of diseased and injured bones from the Pleistocene, Rancho la Brea beds of southern California shown in Fig. 21, a–k, will give an idea of the prevalence of disease in the bones from these periods.

SUMMARY

The above brief summary of paleontological evidences shows that in each geological period there are a few evidences of pathological processes known, although there has been no organized search made for diseased remains. In fact paleontologists as a rule have paid very little attention to evidences of pathology in fossil remains, though the subject is one which yields much that is interesting. The subject increases our vision as to the possibilities of medical history and extends our knowledge of the occurrence of disease back into geological time for many millions of years. No new ideas of pathology have been seen in the study of these ancient lesions—nor were any expected. Since the organization of animal and plant forms of ancient times differ in minute details only from those of recent times there is no reason why we should expect any new ideas. Doubtless many of the lesions described and figured above will on closer examination prove to be lesions of extinct diseases. We know from medieval history that diseases do become extinct and doubtless many of the diseases from which ancient animals suffered are now extinct. Their results, however, as seen in the fossilized bones, closely parallel the pathological anatomy of recent times.

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[9] "Studies in Paleopathology. II., Pathological Evidences of Disease among Ancient Races of Man and Extinct Animals," *Surgery, Gynecology and Obstetrics*, 1918, figs. 1–45.

The question of extinction is still an open problem. A study of the paleontological evidences of disease, as seen in the bone lesions, does not help us much yet in an appreciation of what part disease may have played in extinction. The part may have been great, but this is a hypothetical assumption, based purely on analogy.

The subject of paleopathology and the significance of its study were first commented upon and developed by Sir Marc Armand Ruffer, while studying the lesions seen in Egyptian mummies. A study of fossil lesions is merely an extension of the work began by him but it broadens perceptibly the scope and value of paleopathology.

e, E. I.

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BULLETIN NO. 131 JUNE 1911

AGRICULTURAL EXPERIMENT STATION

SOUTH DAKOTA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS

VETERINARY DEPARTMENT

SCABIES (MANGE) IN CATTLE

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SCABIES (MANGE) IN CATTLE

E. L. Moore

Bulletin No. 107 of this Station, issued by the Department of Veterinary Medicine, contains a report of the results obtained by this department in a co-operative experiment with the United States Department of Agriculture, in order to determine the relative efficiency of the various constituents of coal-tar dips in the treatment of sheep scab. Subsequently, the experiments were continuel in co-operation with the Bio-Chemic Division of the Bureau of Animal Industry, in order to determine the per-centage of the different coustituents of coal-tar dips which should be present to render them effective in the treatment of scabies in cattle. In order to render the results more intelligible to the present reader it will be necessary to repeat portions of the above mentioned bulletin.

In the distillation of bituminous coal there are given off numerous volatile bodies which are condensed into a dark, thick liquid, or semi-liquid substance to which has been given the name of coal-tar. The composition of coal tar is very complex and varies considerably with the temperature at which the distillation of the coal is effected. From among the various products obtained by this distillation we have a large number of so called coal-tar dips, the uses of which have become so familiar. These dips contain a varying per-centage of coal-tar oils and cresylic acid (cresols and other phenols) which are rendered capable of being emulsified by the addition of resin ~~or linseed~~-oil soaps.

While there are at least three different forms of Scabies in cattle the most common one is Psoroptic scabies, and it is exclusively this form of mange which will be under discussion.

The essential cause of this disease is a small parasite known as the Psoroptes bovis which does not differ materially in appearance from the Psoroptes of the horse or of

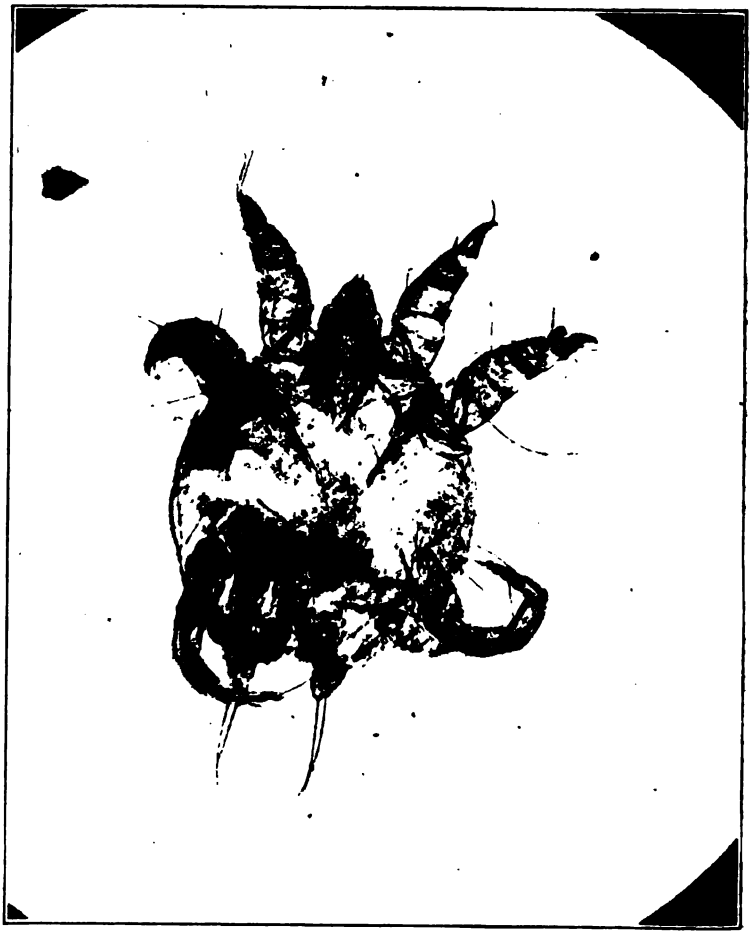

FIG. I.—*Psoroptes bovis*, the parasite producing cattle mange

the sheep. The differentiation of this parasite into various species is based not upon any marked anatomical differences but rather on its adaptability to live only on certain species of animals. Efforts to transfer the Psoroptes from horses to cattle, from cattle to horses, or from sheep to either horses or cattle, have all been accompanied by failure. When transferred from one genus of animal to another they live but a short time, and any eruption which appears recovers spontaneously. Figure I. is from a photo-micrograph of the Psoroptes bovis. Favoring causes are to be found in mal-nutrition and stabling during the winter months. At this period of the year the parasites are driven downward by the cold, attacking the skin and causing greater irritation. It is well recognized by all those who are familiar with this disease that when the stock is turned out to pasture in the spring the irritation largely, if not entirely, ceases, it being maintained that the freer secretions supply the wants of the parasite so that it does not care to bite.

Neumann observed that the Psoroptes exist during the summer, although the cattle appear to be cured. Gerlach and Mueller found the parasites in large numbers around the neck and the horns during the summer months. Knowles of Montana, found the parasites in large numbers during the summer months although there was but a slight amount of skin irritation at that time. Peters of Illinois, records observations made on three different herds in which the disease had existed during the winter, nothing having been done in the line of treatment. During the month of June in every instance, the parasites were found at the base of the horns and on the neck, the animals showing no symptoms whatever of inconvenience. From the latter author we quote, "It may be that these mites seem to disappear during the summer months as the ranchmen have discovered, but from our observations they still infest the animal, but cause no noticeable inconvenience during this time; hence, it must be that they feed on the surface and hair of the animal; whereas during the fall of the year these mites begin to burrow into the skin and produce this intense itching (puritus.)"

SYMPTOMS.

Most frequently the disease appears at the root of the tail, the thighs, or it may be at the neck or withers. Figure II. shows the root of the tail and the thighs to be affected. Later the neck, the shoulders, the sides of the chest or any portion of the entire body with the exception of the legs, may become involved. There is a violent itching or puritus, the animal rubbing itself against all possible objects, and frequently to such an extent as to cause bleeding of the affected portions. A careful examination of a freshly attacked spot shows the presence of small elevations of the skin about the size of millet seeds, which may become confluent and are filled with serum. These break and agglutinate the hair, and drying, form crusts of increasing thickness which become very adherent, and which gradually increase in number, size, and extent. Underneath these crusts, particularly around the margins of the same, may be found the multiplying Psoroptes which can be detected by the naked eyes or better by means of a lens when the crusts are placed on a sheet of black paper in the warm sun. The skin loses its hair and becomes dry, thickened, and marked with crevices or cracks particularly in the region of the neck, shoulders or the chest. A careful study of Figure III. will show this thickening and cracking of the skin over the shoulders, while at the top of the shoulders will be found a more recently invaded area. The affected animals gradually pass into a state of cachexia, becoming emaciated and eventually dying from mal-nutrition.

DIAGNOSIS.

Certain other affections of the skin may possibly be mistaken for Scabies. Lice, will produce violent itching

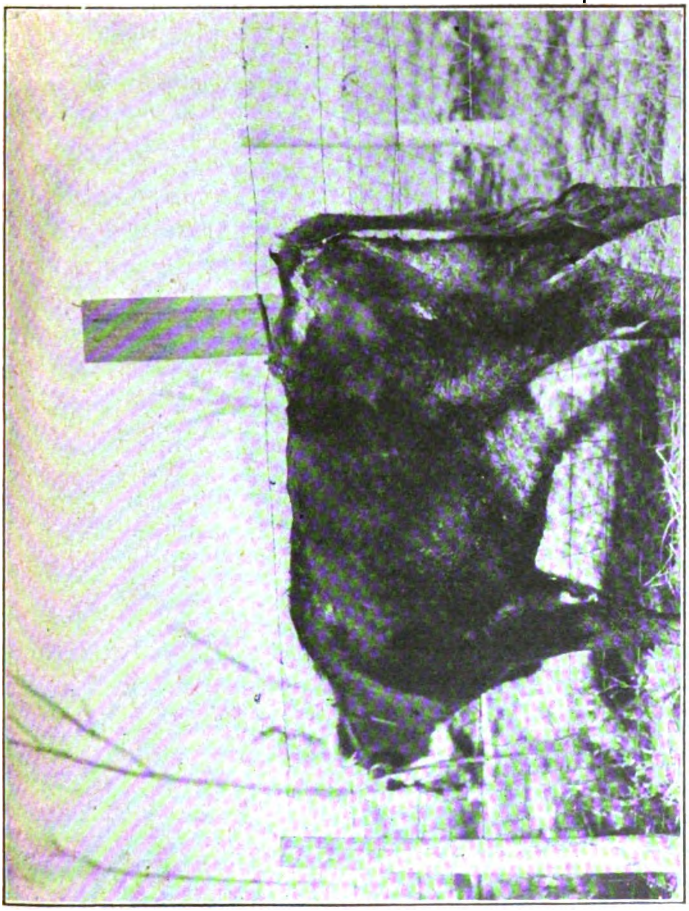

FIG. II.—A typical case of Scabies. Rump, inside of quarters and shoulders affected.

and occasion a loss of hair. There is not, however, the tendency toward the formation of thick crusts as will be found in Scabies. This condition is readily diagnosed by the recognition of the lice which are especially to be found at the base of the horns, the upper portion of the neck or at the root of the tail. It must be kept in mind, however, that these two conditions of Scabies and lousiness frequently co-exist and the examination must therefore be more than a superficial one. In general, however, the line of treatment adopted for Scabies proves effective in the treatment of lousiness.

Ring-worm, found frequently upon calves or it even may be upon adult cattle, produces a well defined circular, scaly lesion, the favorite locations in cattle being in the neighborhood of the eyes and ears. A positive diagnosis of Scabies can of course be obtained only by the recognition of the Psoroptes bovis. For this purpose crusts from the affected portions are to be teased out over a piece of black paper in the direct sunlight and examined preferably with a lens magnifying from ten to twenty-five diameters.

TREATMENT.

In conducting the experiments previously mentioned in the use of coal-tar dips, cattle were purchased affected with Scabies and divided into eight lots. Each lot was separated from the other by an alley of about 24 feet, in order to avoid infection from one lot to the other. The animals were dipped in the cage type of vat, and after each lot was dipped the vat was thoroughly cleansed before another kind of dip was added. The dips used were prepared by the Bio-Chemic Division of the Bureau of Animal Industry and when ready for use contained the following per-centages of cresylic acid and coal-tar oils. (By the term cresylic acid as here used is meant cresols and

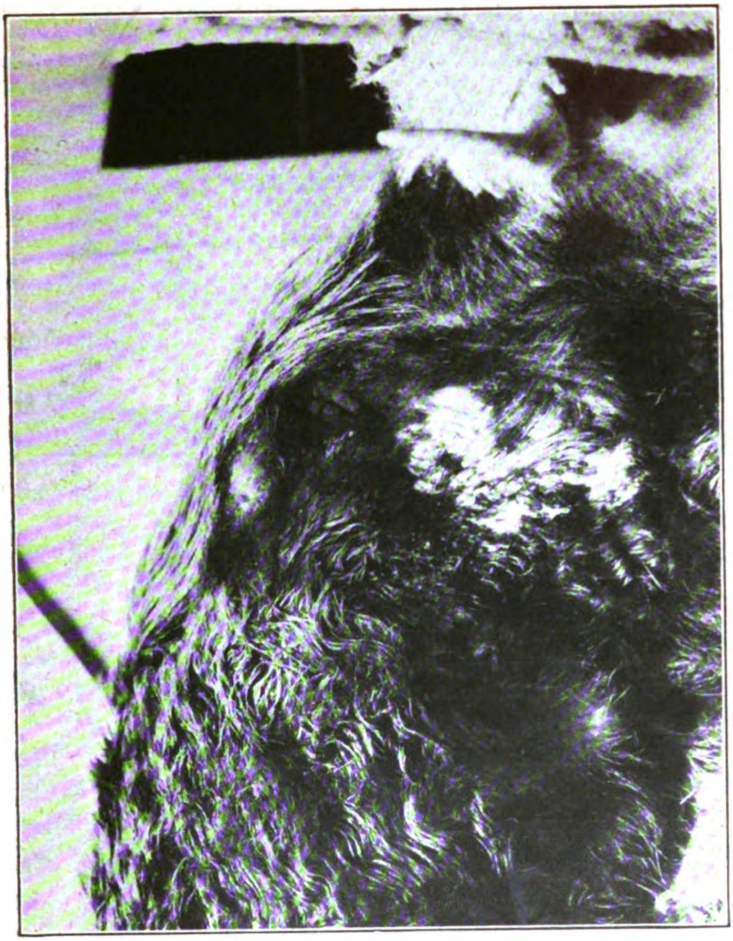

FIG. 111.—Shoulders scabby. Skin of shoulders thickened and furrowed.

other phenols derived from coal-tar, none of which boils below 185 degrees Centigrade nor above 250 degrees Centigrade).

Lot. I. Cresylic acid one-tenth of a per cent, coal-tar oils one and two-tenths per cent.

Lot II. Cresylic acid four-tenths of a per cent, coal-tar oils one per cent.

Lot III. Gresylic acid two-tenths of a per cent, coal-tar oils one per cent.

Lot IV. Cresylic acid five-tenths of a per cent, coal-tar oils none.

Lot V. Cresylic acid three-fourths of a per cent, coal-tar oils none.

Lot VI. Cresylic acid one per cent, coal tar oils none, kerosene one and two-tenths per cent.

Lot VII. Cresylic acid one per cent, coal tar oils none, crude petroleum one and two-tenths per cent.

Lot VIII. Controls, untreated.

It will thus be seen that three different classes of dips were used in this experiment. Lots 1, 2 and 3 were treated with coal-tar cresote dips, that is they contained coal-tar creosote or coal-tar oils and cresylic acid; lots 4 and 5 were treated with a cresol dip; while lots 6 and 7 were treated with a cresol dip to which was respectively added kerosene and crude petroleum.

Owing to unavoidable delays considerable time elapsed between the purchase of the cattle and the dipping, and at the time when the dipping actually occured many of the animals showed only a slight infection. For this reason the apparently favorable results obtained in the first four lots of cattle have not been deemed trustworthy.

Summarizing the results otbained, lots one to four, inclusive, remained free from Scabies for one year after dipping. The lice, however, with which these cattle were infested, at the time of dipping, were not eradicated. The cattle contained in lots five to seven inclusive, remained scabby after treatment. It will thus be seen that the results obtained through the use of Cresol dips in the treatment of Scabbies in cattle are entirely at variance with those obtained in the use of the same class of dips in the treatment of sheep scab. While the coal-tar dips in solutions similar to those used above were found effective in the treatment of sheep scab, their use can by no means be recommended in the treatment of Scabies in cattle. Mercurial or arsenical dips should be avoided on account of the danger of poisoning from absorbtion through the skin as well as from that of poisoning through the bovine habit of licking themselves.

Undoubtedly, therefore, the best results in the treatment of this affection are to be obtained through the use of tobacco and sulphur or lime and sulphur preparations.

The tobacco and sulphur dip is the same as that used for sheep scab, that is, there should be sufficient extract of tobacco or nicotine solution to give a mixture containing not less than five one-hundredths of one per cent of nicotine and sufficient sulphur to give a two per cent solution.

The lime and sulphur dip contains more lime than when made up for the treatment of sheep scab. It should contain 12 pounds of unslacked lime and 24 pounds of flowers of sulphur to 100 gallons of water. The lime is to be placed in a mortar box and sufficient water added to slack the lime and form a sort of paste or putty. To this the finely sifted sulphur is added and the mixture thoroughly stirred.

This is then placed in a boiler, 30 gallons of water added and the mixture boiled for at least two hours with frequent stirring, occasionally adding fresh water to retain the original quantity. This is then placed in a cask or other receptacle and allowed to settle for several hours. When fully settled the clear liquid is drawn off into the

vat and sufficient water added to bring the total quar
up to 100 gallons. Owing to the labor involved in pr
ing the tobacco and sulphur, and lime and sulphur
many prefer to make use of some one of the proprie
products. The purchaser should, however, assure hi
that the dip he contemplates using has the approval o
Department of Agriculture, as shown by a label sta
that the manufacturers of that dip guarantee the con
to be of the same composition as the sample submitte
the Department of Agriculture.

In those cases where failures have been reporte
lowing the use of either of these dips when properly
pared and used, it can readily be shown to have been
ed through returning the dipped animals to infested
rals, yards, etc., or from re-infection from other catt
the range.

Irrespective of the kind of dip employed the follo
general directions should be adhered to:

1. The temperature of the dipping vat should be
stantly maintained at from 103 degrees F. to 105 degre

2. Animals badly affected are preferably to be
dressed by scrubbing the scabby areas with a stronger
tion of the dip. Where lime and sulphur is used this
the effect of softening the firm scab allowing the di
penetrate.

3. Each animal should be held in the vat for
minutes, and completely immersed twice.

4. All animals that have been in contact with
diseased ones should be regarded as infected and dip

5. The dipping should be repeated in from ten
fourteen days to destroy the parasites that may have ha
ed out subsequently to the first dipping.

6. Dipped cattle should not be returned to inf
stables or corrals.

The type of vat to be employed will be largely governed by conditions. Where only a small number of animals is to be treated the dip can be successfully applied by means of a brush or a spray pump. For larger numbers the cage type of vat costing from $125 to $200 may be employed. In this type of vat two or three animals are crowded into a cage which is then lowered into the vat. Throughout South Dakota however, the swimming type of vat has been more generally used. The animal is crowded forward on a trap which is then sprung precipitating it into the vat, through which it swims emerging by an inclined plane to the dripping floor.

The problem of stamping out this disease in cattle in the State of South Dakota has been a very serious one. By the method of treatment outlined Scabies has been eradicated from the eastern portion of the state so that at present a quarantine is maintained by the United States Department of Agriculture only against that portion of South Dakota lying west of the Missouri River. In those portions of the State where the farms are entirely enclosed and there is no mingling of the herds of different owners, no particular difficulty is encountered. Where, however, semi-open or range conditions exist eradication becomes more difficult. This is brought about by the difficulty, if not impossibility, of establishing a strict quarantine of undipped and of exposed herds. Perhaps one man has carefully dipped his cattle so as to eradicate the disease; but his neighbors whose cattle have also been exposed to infection, refuse to dip. Under semi-open or range conditions these cattle intermingle to a greater or less extent in spite of attempts to establish a quarantine, so that the dipped cattle become newly infected. In the experience of the writer just such factors have been largely instrumental in preventing the complete eradication of the disease in this state. It is, however, exceedingly gratifying to note that under the effective system of quarantine and inspection maintained by the Bureau of Animal In-

dustry in co-operation with our State Live Stock Sanita
Board that the diesase is becoming largely eradicated a
we can confidently look forward to that time in the ne
future when the quarantine will be raised from the enti
State of South Dakota.

LIST OF AVAILABLE BULLETINS

89. Preliminary Experiments with Vapor Treatments for the Prevention of Stinking Smut in Wheat.
90. Tankage and other By-Products for Pigs; Shrunken Wheat for Swine.
91. Co-operative Vegetable Tests in 1904; Peas, Beans, Sweet Corn. Cabbage.
92. The Milling Qualities of Macaroni Wheat.
94. Alfalfa and Red Clover.
95. The Treatment of Nail Pricks of Horse's Foot.
96. Forage Plants and Cereals at Highmore Sub-Station.
97. Speltz and Millet for the Production of Baby Beef.
98. Crop Rotation.
99. Macaroni and Durum Wheats. A continuation of Bulletin 92.
100. The Value of Speltz for the Production of Beef and Pork.
101. Forage Plants at the Highmore Sub-Station, 1906.
102. Evergreens for South Dakota.
103. Breeding Hardy Strawberries.
104. Breeding Hardy Raspberries.
105. Stock Food for Pigs.
106. Sugar Beets in South Dakota.
107. Sheep Scab.
108. New Hybrid Fruits.
109. Rusts of Cereals and other Plants.
110. Progress in Variety Tests of Oats.

111. A Study of South Dakota Butter with Suggest for Improvements.

112. The Killing of Mustard and other Noxious W in Grain Fields by the use of Iron Sulphate.

113. Progress in Variety Tests of Barley.

114. Digestion Coefficients of Grains and Fodders South Dakota.

115. Report of Work for 1907 and 1908 at Highmore Station.

116. Acidity of Creamery Butter and its Relation Quality.

117. Sugar Beets in South Dakota.

118. Corn.

120. Progress in Variety Tests of Alfalfa.

121. Sugar Beets in South Dakota.

122. Creamery Butter.

123. Milk Powder Starters in Creameries.

124. Progress of Grain Investigations.

125. Fattening Steers of Different Ages.

126. Alkali Soils.

127. Breeding and Feeding Sheep.

128. Progress in Wheat Investigations.

129. Growing Pedigreed Sugar Beet Seed in S Dakota.

130. Some New Fruits.

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With the author's compliments

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EGG-LAYING CAPACITIES OF MALARIA MOSQUITOES.

BY

⑤

H. W. B. MOORE, F.E.S.

Malaria is still our worst disease, and in its manifold evil consequences, is a eat handicap to progress, agriculturally, and otherwise. It takes a greater toll f life than does any other disease, not only directly but indirectly, by being the ot cause of several serious disorders. Then again there is the loss of service e to the attacks. No one, debilitated through malaria in whatever manner, n give of his best, quite apart from compulsory absences from work. Only ear before last the labour arrangements of one of our largest sugar plantations ere gravely disorganized by malaria suddenly swooping down in epidemic form. f course, the outbreak was an exception, but was, nevertheless, a very forcible bject lesson on the supreme danger of the disease, which, as is now almost comonly accepted knowledge, is spread by certain species of mosquitoes.

Accordingly, the study of these mosquitoes ought to be of paramount oncern. The insects may be regarded as enemies to the community in general, nd consequently the public at large cannot know too much about them.

Malaria mosquitoes are frequently spoken of as Anophelines. On the coast ere are two of them, viz., *Anopheles tarsimaculatus* Goeldi, and *Anopheles rgyrotarsis* R.—D. The former, which is usually the commoner, has a black pot-like bar in the white at the end of the hind legs, whereas with the latter the erminal joints of the hind legs are just a plain silvery white. The mosquitoes, t may also be stated, are long and narrow, and in resting or in drawing blood ave the peculiar habit of perching upright—standing on their heads as it were— n which posture they have aptly been compared to projecting thorns.

Much has already been written by various specialists and others as to the est means of controlling the mosquitoes. Of these measures however, the present rticle will take no note. It will be concerned with but a single phase of their ife-history, viz., their egg-laying capacities. For long there had existed the esire to make observations in this direction as an attempt to secure what may be onsidered a tolerably reliable idea of the number of eggs the mosquitoes may be xpected to lay in a state of nature. A good opportunity for doing so first came n the middle of 1926, when malaria mosquitoes—all *tarsimaculatus*—were airly noticeable about my quarters in the country. The plan was to secure orged specimens and enclose them for egg-laying purposes in suitable receptales. After they had oviposited, they were allowed to draw blood again, and gain confined for egg-laying, and so on according as they would draw blood and oviposit. Gorged specimens were obtained by searching window-panes an bed-curtain on mornings, and by placing a small glass tube over any mo seen in the act of attacking, and allowing it to slake its sanguinary thirst full, when it would be kept as a prisoner. In these ways half-a-dozen mosq were captured and ordinary pint tumblers served excellently as receptacl confinement, a piece of paper punctured with holes by a needle teaser bein over each glass as a cover. On the water in each vessel there were also three or four small pieces of grass or of dried cane-trash, while two or thre pieces were put to stand on end. The pieces of grass or trash were intend the mosquitoes to perch on should they so desire, either for rest or in egg- For rest, however, they usually hung on to the paper cover.

The observations on the egg-laying of these mosquitoes, and certain ments with the eggs in regard to whether or not they could resist pro desiccation, were recorded in the "*Daily Argosy*" of August 11th, 1926, a not here recounted. It need now only be mentioned that one of the mos drew blood three times successively and oviposited after each blood mea which were all fertile, the total number having been 435. It seemed stupendous number of eggs to be laid by a single mosquito, but the app astounding feat was far and away eclipsed by *Anopheles argyrotarsis*, no the egg-laying of which are hereunder recorded.

It was last July and August that malaria mosquitoes—all *argyrotarsis* again annoying in considerable numbers in bright sunshine in a few field section of one of our sugar plantations.

Between 9 and 10 o'clock in the morning of Wednesday, July 18th, si mosquitoes were captured attacking two of the East Indian lads who assist sugar-cane entomological work of the plantation. Between the same hours morning of Wednesday, August 22nd, three more of the mosquitoes were t they attacked the writer. The captured insects which will be designate 1-9 were all used for egg-laying purposes, after the manner already desc

In all cases the insects when drawing blood at the time of capture what is considered as the characteristic thorn-like attitude, as they did, too resting anywhere about the glass. At subsequent imbibitions, howev when resting on the sides of the glass or on the trash, they began to assume or less crouching attitude, which eventually somewhat simulated that of M They seemed unable to maintain throughout the stilted posture. At t of their death, too, the insects that had lived longest had lost a large nu their scales through beating about the receptacles so that they presented curious nude appearance.

The egg-laying of the mosquitoes taken on Wednesday, July 18th, w be dealt with. At 6 a.m. on Sunday 22nd it was seen that Nos. 1-4 had la

Oviposition had occurred most probably in the early hours of the same morning, the pale colour of the majority of the eggs being indicative of quite recent extrusion. The eggs had thus been laid between three and four days after the insects had drawn blood. Nos. 1 & 2 had died after ovipositing. The eggs laid by each insect were counted, and it was found that 234 had been laid by No. 1, 174 by No. 2, 162 by No. 3, and 220 by No. 4.

At 8 o'clock on the Sunday morning a finger was presented to No. 3 by raising the paper cover of the glass just enough to admit the finger. The insect at once alighted upon it and drew blood. At 8.20 a similar operation was carried out in the case of No. 4, which, however, managed to escape after it had gorged itself.

On Monday 23rd, it was noticed that Nos. 5 & 6 had laid eggs early that morning or during the Sunday night. In these cases oviposition had therefore taken place between four and five days after the insects had imbibed blood. 238 eggs had been laid by No. 5, and 269 by No. 6. No. 5 immediately drew blood from a finger at 1.30 p.m. on the same day, while No. 6 had done the same at 10 a.m.

The eggs of Nos. 1-4 were found hatching at 6 a.m. on Tuesday 24th, and of Nos. 5 & 6 on Wednesday morning, i.e., in each case about two days after having been laid.

No. 3 again oviposited on the night of the 24th or in the early morning hours of the 25th, i.e., between two and three days after drawing blood. The number of eggs laid was 162. It again drew blood at 1 p.m. on the 25th.

On Friday 27th it was seen that No. 5 had laid only 98 eggs the previous night, and that the abdomen had not completely collapsed. However, it drew blood again at 6.40 a.m. On the same morning it was also found that No. 6 had laid 118 eggs the previous night. It again drew blood at 7.15 a.m. In each case oviposition had occurred between three and four days after the blood meal.

On the morning of Saturday 28th it was seen that No. 3 had laid 82 eggs—most likely early that morning, i.e., between two and three days after having drawn blood. Of the eggs only eight were floating on the surface of the water. The rest were in two heaps at the bottom of the glass, and as far as could be seen. had no buoyancy sacs. One heap contained 54 eggs which were black or darkish, the other 20, all of which were white and remained so. It was not expected that any of these would hatch—certainly not the white ones. As to the insect itself, it was observed struggling on its back on the surface of the water, as though it might have been dying. On being rescued, however, from its predicament by means of a piece of dry trash, and transferred to an empty glass, the apparently dying creature, after a few frantic efforts at flight, did actually fly, and would have escaped had I not quickly placed the palm of my hand over the glass. It at once set about drawing blood. This was between 9 & 10 a.m. O the morning of Sunday 29th, the insect was seen to fall sometimes to the botto of the glass, where it would struggle on its back. It was obviously getting weak and weaker. On a little water being introduced it alighted upon one of the d pieces of trash always supplied as rests, as already stated, seemed to sip eager of the water, and then flew up to the paper cover. The next morning it w found struggling on its back in the water, and this time when rescued and p into a dry glass failed to right itself. On the morning of Tuesday 31st it w found dead. It had therefore lived 12 days from the date of capture, and h laid a total of 406 eggs.

On the night of Saturday 28th No. 6 laid 167 eggs, i.e., less than two da after drawing blood. Still looking lively it imbibed blood again immediately 8.17 a.m. on Sunday 29th. On the morning of Monday 30th it was observ that No. 5 had laid during the previous night 191 eggs, or over 2½ days from t last blood meal, and thus also made up for the paucity of eggs remarked upon the preceding oviposition. It still seemed full of life, and at once imbibed mo blood at 6.50 a.m.

It was also noted that at least one of the eggs which had been laid by No. on the 27th and had sunk to the botton had hatched. Possibly it had been fully developed egg that had been dragged down by the weight of the rest of t mass. None of the other sunken ones hatched.

On the morning of Wednesday August 1st, it was ascertained that No. had laid on the Tuesday night 131 eggs. At noon it again drew blood, but on after a pause of some two or three minutes, during which it seemed either to deliberating what to do, or not to know it was on a living object until the fing was vigorously shaken.

No. 5 which had drawn blood on Monday, July 30th, oviposited only on t night of Friday August 3rd, i.e., after an interval of fully 4½ days. The numb of eggs laid was 176. It still appeared endued with a deal of life, and in pro thereof again drew blood immediately at 12.30. p.m. on Saturday the 4th. T eggs laid on the Friday night were hatching on the Sunday night. On the mor ing of Tuesday the 7th, it was observed that it had laid 90 eggs on the Mond night. Unfortunately, owing to pressure of time, coaxing it to draw blood aga had to be a hurried affair, and the insect succeeded in escaping. It was yet qui active, and no doubt would eventually have been got to imbibe blood agai Anyhow, it had drawn blood five times successively, and laid eggs after ea imbibition, the total number being 793, all of which were fertile.

On the night of Saturday the 4th No. 6 laid 112 eggs, and drew blood aga immediately at 9 a.m. the next day. On Wednesday morning the 8th, at sunri it was observed that the eggs were hatching. On the morning of Thursday t 9th it was seen to have laid 137 eggs the preceding night, and to be feebly stru gling on the surface of the water. Its end had come. It died later in the day. It had lived 22 days from the time of its capture, had drawn blood six times in succession, and had oviposited after each blood meal, the total number of eggs being 934, all of which proved fertile.

The egg-laying of the three mosquitoes captured in August will now be reviewed. As already stated, they were taken between 9 and 10 a.m. on the 22nd.

On the morning of Saturday 25th No. 7 was found dead. It had laid only 47 eggs. No. 9 was also found dead on the Monday morning, after having laid but 43 eggs on the previous night.

On the morning of Sunday 26th it was seen that No. 8 had laid 210 eggs on the Saturday night. It drew blood at once again at 7.30 a.m., and, after laying 107 eggs on the night of Tuesday 28th again imbibed blood at 1.30 p.m. on the 29th. On the Friday night, the 31st it laid 141 eggs, and, after giving a little trouble to be got on to the finger presented, again drew blood at 2.10 p.m. on Saturday, September 1st. It laid 146 eggs on the night of Tuesday 4th, and again drew blood without delay at 3.15 p.m. on Wednesday 5th. On the night of Friday 7th, it laid 116 eggs, and again unhesitatingly imbibed blood at 2.30 p.m. on September 8th. On the night of Tuesday 11th it laid 154 eggs, and yet again immediately drew blood at 6.45 a.m. on Wednesday 12th. On the morning of Saturday the 15th, it was seen to have laid 129 eggs on the Friday night, and to be sprawling, as though dead, on the surface of the water. On being touched it was found, however, to be still alive, and was transferred, feebly struggling, to a dry glass where it died in the early afternoon. It had therefore lived for 24 days from the time of its capture, had drawn blood seven times in succession, and deposited a total of 1,003 eggs. All of the eggs were proved fertile.

In connection with the egg-laying of the mosquitoes the following table may prove helpful.—

Mosquitoes	*Drew Blood*	*Laid Eggs*	*No. Eggs Laid*
1.	July 18th.	July 21st.	234
2.	July 18th.	July 21st.	174
3.	July 18th.	July 21st.	162
	„ 22nd.	„ 24th.	162
	„ 25th.	„ 27th.	82—406
	„ 28th.	„ —	—
4.	July 18th.	July 21st.	220
5.	July 18th.	July 22nd.	238
	„ 23rd.	„ 26th.	98
	„ 27th.	„ 29th.	191
	„ 30th.	Aug. 3rd.	176
	Aug. 4th.	„ 6th.	90—793

6.	July 18th.	July 22nd.	269
	„ 23rd.	„ 26th.	118
	„ 27th.	„ 28th.	167
	„ 29th.	„ 31st.	131
	Aug. 1st.	Aug. 4th.	112
	„ 5th.	„ 8th.	137—934
7.	Aug. 22nd.	Aug. 244th.	47
8.	Aug. 22nd.	Aug. 25th.	210
	„ 26th.	„ 28th.	107
	„ 29th.	„ 31st.	141
	Sept. 1st.	Sept. 4th.	146
	„ 5th.	„ 7th.	116
	„ 8th.	„ 11th.	154
	„ 12th.	„ 14th.	129—1003
9.	Aug. 22nd.	Aug. 26th.	43

It should be remembered that Nos. 1, 2, 7 and 9 died after laying eggs once, that No. 3 died without ovipositing after its fourth meal of blood, that 4 and 5 escaped and that Nos. 6 and 8 died after their sixth and seventh b meal respectively.

CONCLUDING REMARKS.

From the above observations it may be specially noted :—

(1) That the natural egg-laying capacity of the mosquitoes is enormous, would probably be about the same in each species—*tarsimaculatus* and *arg* *tarsis.*—To place it in the vicinity of 1,000 eggs per individual would hardly an exaggeration. It may be recalled that two mosquitoes captured at random of what must at least have been many hundreds laid 934 and 1,003 eggs respecti so that anything between 900 and 1,000 per individual may safely be regarde quite normal. Another taken out of thousands laid 793 eggs and would probably have been got to lay several more had it not escaped. With such egg-laying powers, apparently exceeding by a long way those of the dre small moth-borer of the sugar-cane, wonder should cease at the great swar malaria mosquitoes which now and then are to be witnessed in various par the colony, particularly after a drought when natural controlling agencies ma at a discount and natural conditions otherwise favour multiplication.

(2) That the mosquitoes can draw blood to satiety for upwards of at seven times in succession, and oviposit after each meal.

(3). That, as is the case, say, with spiders, the production of fertile eg each oviposition is not dependent upon the attentions of a male. No d copulation is a first essential for the production of fertile eggs, but, no d too, a single copulation can serve for all eggs to be produced. Since al mosquitoes captured laid fertile eggs, copulation under nature must be general with them, and probably be one of the first acts done on the emergence of the insects from their breeding-grounds. Besides, it may be presumed, making the females bolder and more vicious, it would certainly ensure that they are fertile eggs.

(4) That the time between blood-feeding and egg-laying, and again between egg-laying and egg-hatching is very short, ranging in the former case from under two days to nearly five, and in the latter from under two to about three.

(5) That the insects are ready to imbibe blood soon after oviposition.

In some cases eggs had obviously been laid not long before sunrise, and not long after sunrise the mosquitoes drew blood, as a rule, without hesitation.

(6) That captive mosquitoes fed promptly and regularly with blood may live for over three weeks. It would be interesting also to ascertain whether or not delayed feeding would extend or diminish the life of the insects, just as it would also be a point of interest to breed carefully mosquitoes from the various batches of eggs so as to determine the proportion of the sexes in each batch.

THE ANATOMY

OF

BDELLODRILUS ILLUMINATUS

AN AMERICAN DISCODRILID

BY

J. PERCY MOORE

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1895

THE ANATOMY OF BDELLODRILUS ILLUMINATUS, AN AMERICAN DISCODRILID.

J. PERCY MOORE.

Introduction. — The present paper is devoted to a description of the general anatomy of Bdellodrilus illuminatus, without much attention to histological detail, or any discussion of the special evidence which this species affords, *pro* and *con*, on the matter of current views regarding the zoölogical relationship of the family. The latter is reserved for a future paper, which awaits the completion of embryological studies now in progress, as well as a more thorough knowledge on the part of the writer, of the extensive literature of oligochaete and hirudinian anatomy.

Bdellodrilus illuminatus was originally described, under the tentative name of Branchiobdella illuminata, in the Proceedings of the Philadelphia Academy of Natural Sciences, 1893, p. 421; since which time more thorough anatomical studies, and the examination of additional native species of Discodrilidae, and of the European Branchiobdella parasita (specimens of which were kindly obtained for me by my brother, Mr. H. F. Moore, from Dr. Anton Collin), have forced me to the opinion then entertained, that this species should constitute the type of a distinct genus.

This it is proposed to name Bdellodrilus, as being at once suggestive of probable affinities with the Oligochaeta, and of special structural modifications in the direction of the leeches.

The genus is defined by the possession of the following characters, all of which distinguish it from Branchiobdella. There are two pairs of testes and two pairs of vasa deferentia occupying the fifth and sixth post-cephalic somites. The anterior pair of nephridia open to the exterior by a common pulsatile vesicle. The dorsal and ventral jaws are quite dissimilar. Branchiobdella possesses but one pair of testes and ducts, separate nephridial pores, and similar dorsal and ventral jaws.

Of described species two belong to Bdellodrilus, *viz.:* B. illuminatus, and B. philadelphicus = Astacobdella philadelphica Leidy (Pro. A. N. S. Phila., 1851, p. 209). Briefly these are distinguished as follows: B. illuminatus — Head narrower than the tapering anterior body segments. Dorsal jaw a compressed dentigerous ridge, passing between the large paired teeth of the lower jaw. There are nine pairs of conspicuous lateral glands in the nine anterior body somites. Spermatheca slender, and bifid dorsally. Penis freely eversible. B. philadelphicus — Head much broader than the anterior body segments. Both jaws triangular, the dorsal provided with a single apical tooth, the ventral with a pair of smaller ones. No lateral glands. Spermatheca broad, thin-walled, and sub-cylindrical. Penis proper not eversible, but carried to the exterior by the eversible bursa, into which its projecting end is received. A conspicuous prostate, in addition to a large glandular sperm-sac.

In the matter of technical manipulation Bdellodrilus illuminatus offers somewhat greater difficulties than other Discodrilidae. These arise chiefly from the presence of the relatively enormous lateral mucous glands, which envelop the resting body in a mass of glairy secretion, interfering with the ready penetration of fixing fluids. The best preparations for anatomical study were obtained by suddenly pouring over active individuals hot corrosive sublimate solutions, especially that recommended by Lang for fixing planarians. The latter caused instant death and complete extension. Flemming's chromo-aceto-osmic acid mixture gives the usual excellent results as regards fidelity of fixation of histological structures, and is particularly useful in the study of spermatogenesis, for which the Discodrilidae are favorable subjects (see Voigt). For the special study of the chlorogogue cells osmic acid is useful. Perenyi's fluid, Merkel's fluid, potassium bichromate, chromic acid, and picro-sulphuric acid did not give useful results with this species, though not objectionable with B. philadelphicus and other species. Narcotization with chloroform was successful; while alcohol was worthless for this purpose. As to stains, either Delafield's or Kleinenberg's haematoxylin gave the best general results. Biondi-Ehrlich was particularly valuable for differentiating glands, for tracing nerves among the muscles of the body-walls, and in studying the testes and ovaries. Borax carmine occupied its usual important place among general stains. Methylene blue was also used as a nerve tracer. The results obtained from a study of many series of sections were further verified on living material, mounted preparations of entire worms, and teased preparations.

External form. — The rounded club-shaped body is terminated anteriorly by the so-called head, and posteriorly by the sucker. The head is narrow and is less sharply distinguished externally from the following segments, than is usual in the family (Fig. 1). It consists of four annuli, which, there is reason to believe, represent as many somites. The first, or peristomial annulus is divided into very mobile dorsal and ventral lobes or lips, which exhibit slight median emarginations, but are otherwise entire; and lack the sensory hairs and papillae which are usual in this family. There is no prostomium. The fourth cephalic annulus is very narrow; and when the animal is contracted, is completely hidden beneath the overlapping anterior margin of the first body somite, into which it is drawn by the longitudinal muscles. The remaining two, the second and third, appear externally as simple muscular rings.

The body proper consists of eight strongly bi-annulate somites, posterior to which three crowded, but still obscurely bi-annulate somites, form the posterior sucker and its support (Fig. 1, 1 to 11). These increase in diameter, gradually, from the first to the seventh, and then decrease rapidly to the posterior sucker, which is part of the eleventh somite. Each of the body somites, with the exception of the last, is conspicuously divided into an anterior major, and a posterior minor annulus; the former are much longer, as well as broader, than the latter, and appear more prominently so the greater the degree of contraction, which results from the peculiar manner in which the minor annuli are telescoped within the anterior margins of the major annuli following, as well as to the more prominent bellying of the free hypodermis when the longitudinal muscles shorten.

Of the body somites, the fifth, sixth, and seventh are the sexual; the first four and the eighth nephridial. The external opening of the anterior pair of nephridia is readily seen on the mid-dorsal line of the major annulus of the third post-cephalic somite (Fig. 1, *nv*), and the paired pores of the posterior pair in a dorso-lateral position between the eight and ninth somites. Of the three enlarged sexual somites the sixth and seventh are rendered opaque by the great development of aggregations of unicellular glands constituting a clitellum. On the fifth a slight swelling on the ventral surface of the major annulus indicates the position of the external spermathecal opening, and a more prominent enlargement of the corresponding region of the succeeding segment the mouth of the copulatory bursa (muscular atrium) (Fig. 1, ♂). The external ovipores are relatively minute apertures ventrally located on each side of the seventh somite (Fig. 1, ♀), between the major and minor annuli. The anus opens on a small lobate papilla on the dorsum of the tenth somite (Figs. 1 and 5, *a*).

Bundles of ductules arising from the huge mucous glands which occupy the lateral regions of the nine anterior segments, pierce the hypodermis, and open on the surface of the body in the dorsal and ventral quadrants of the major annuli. The sucker-bearing somites are much crowded; and bi-annulation is only obscurely indicated. The acetabulum itself is a complex muscular ring or disk, having a slight posterior concavity. Its centre lies in the same axis as the body somites, so that in a position of rest the body of this species is strongly arched, instead of resting extended along the surface to which it is attached, as is the case with the species having depressed forms and ventrally directed suckers, which live on the broad surfaces of the chelae and carapace of crayfish.

Body walls.—The body walls are made up of the usual succession of an epidermis with its continuous cuticular covering, an external layer of circular muscle fibres, and an internal more powerful layer of longitudinal muscle fibres. The delicate cuticle is quite continuous, and follows the epidermal cells by which it is secreted into all the external folds, and the oral, anal, and sexual invaginations. It is transparent, colorless, non-iridescent, and under low powers apparently homogeneous ; and maintains on the exterior a uniform thickness of .0015 mm. By prolonged maceration in water it may be easily separated as a continuous piece much larger than the body which it enveloped, and with the tubular invaginations all everted. Surface views of such preparations show very distinctly the minute perforations and the cruciform markings which so generally characterize the cuticle of Oligichaeta ; and which Voigt has described for Branchiobdella. Into the oral invagination and through the pharynx the cuticle extends with undiminished thickness, to terminate a short distance within the first post-cephalic somite, after thinning to an excessively delicate ragged edge. Conspicuous dorsal and ventral hollow thickenings in the anterior region of the pharynx form the jaws. The dorsal jaw is a medium longitudinal ridge bearing on the free compressed margin three posteriorly directed teeth. This is borne by a cuticular plate which anteriorly passes into a pair of slightly divergent ridges, and posteriorly forms a single median piece, passing on all sides into the unthickened cuticle. The entire structure is molded on an epithelial thickening, over which the supporting plate is bent at an obtuse angle, the limbs of which embrace the muscular supporting pad anteriorly and posteriorly, and afford points of attachment for the protractor and retractor muscles (Fig. 9, *dj*). The maximum elevation of the dentigerous ridge is .01 mm., which is about twice the actual thickness of the cuticle at this point. The ventral jaw consists of a pair of similar parallel ridges, united posteriorly by a heavy cross bar, and passes anteriorly, after diminishing in thickness, into the unmodified cuticle. Each ridge bears at its most prominent point a strong claw-like tooth. The muscular pad supporting the ventral jaw is embraced in a manner similar to the dorsal one (Fig. 9, *vj*). The mechanism of the jaws is explained below. There is a very short anal extension of the cuticle, which reaches into the intestine scarcely to the anterior border of the anal segment. No cuticular lining is apparent in the ovipore, and only a very delicate one in the spermatheca. The everted atrial cuticle consists of a bulbous enlargement which belongs to the bursa, and a slender tubular portion which lines the penis.

The epidermis consists of ordinary epithelial cells, of non-nucleate protoplasm, and of gland cells, which are present in great number and variety. The epidermis proper presents little modification. The cellular elements are arranged with relation to the circular muscle fibres, which encircle the body walls at regular intervals and are so deeply imbedded in the epidermis that they are frequently almost in contact with the cuticle, only a thin layer of protoplasm (less than the diameter of a nucleus in thickness) separating them. Between these muscle fibres the cells are arranged in zones, which are still further broken up into groups by communicating branches which pass between adjacent fibres (Fig. 3). The epidermis may be described as made up of small irregular groups of cells united by an external sheet of non-nucleated protoplasm ; the cells lie between the muscle fibres, the non-nucleated protoplasm extends over them (Fig. 2). The entire external stratum of the epidermis exhibits a fine vertical striation, doubtless connected with cuticle secretion. (Fig. 2, *sl.*) Small spaces (*s*), extending from intercellular spaces of the cellular zones, are occasionally seen in the non-cellular regions ; and dark lines, *d*, which I am unable to account for, are more frequent. The cells are cubical and possess cell walls which are well marked internally, but obscure peripherally in the striated layer. The nuclei are large and deeply staining ; and possess one or usually several nucleoli. Among the cells the transparent ductules of unicellular glands wind their irregular or spiral courses to the surface. In thickness the epidermis varies from an average of .009 mm. in the non-cellular region to .018 mm. in the cellular.

Anterior to the jaws there is no modification of the oral epithelium, but within the pharynx it undergoes a marked change, owing to the encroachment of the radial muscles, which penetrate between the cells almost, if not quite (in part) to the cuticle (Figs. 9 and 11, *ep* and *rm*). Between the branching inner ends of these muscle cells the pharyngeal epithelium extends as deeply staining nucleated processes of protoplasm, which often lose their distinct cellular boundaries. The epithelium is largely displaced ; and sections often show a predominance of muscular over epithelial elements in this layer.

Glands are very richly developed in connection with the epidermis of B. illuminatus ; and while all are constructed of similar elements, they differ much in the size and arrangement of these elements. The elements are unicellular glands somewhat of the goblet cell type. In most cases they consist of an enlarged irregularly polyhedral body containing the nucleus, and tapering at one end into a slender, more or less elongated, ductule. The only exceptions are those glands which are referred to as salivary and bursal glands.

Certain small mucous glands are very generally distributed over the skin ; especially on the head, where they are regularly arranged in several transverse rows. They may be unicellular, or consist of three or four unicellular glands, the ductules of which are twisted or spiral.

On the sixth and seventh somites such glands become greatly increased in number and size; the body walls, particularly on the dorsal side, being little more than a thick glandular layer, which constitutes the clitellum (Fig. 4). The unicellular glands are here aggregated in sub-globular or pyriform groups of from three to twenty or more, which extend inward to a length of from .03 mm. to .065 mm. Being arranged in a single stratum each cell forms part of the surface of the gland, close to which lies the deeply staining nucleus, in a mass of almost as deeply staining granular protoplasm. The inner ends are granular but clear and often unstained, and pass into ductules, which may be bound together into a fascicle, and either open in close proximity on the surface, or separate and open singly. In either case they wind a slightly spiral course, which is best seen in living animals, particularly when stained with methylene blue. The cell bodies have an average diameter of .011 mm., the ductules of .0018 mm., and a total length of about .05 mm.

The several cells in each group appear not to function simultaneously. Some have completely broken down into secretion while others are entirely protoplasmic. Voigt's figures of Branchiobdella show this well.

The clitellar glands are arranged in crowded transverse rows between the circular muscle fibres, which are often displaced and carried inward in a highly developed clitellum. On the dorsal side, particularly of the major annuli, the glands are much crowded and of elongated pyriform shape; while elsewhere they are more scattered and globular.

Two or three pairs of large glandular masses are developed in the pharyngeal region of the head. These are of irregular shape, and occupy the spaces between the radial muscles around the pharynx; the halves of each pair almost touch dorsally, and extend laterally and ventrally nearly to the nerve ganglia, while the several pairs are separated by strong muscular bands. The component cells are larger than those of the clitellar glands, and very irregular; they contain an irregular nucleus, protoplasmic strands, and granular cytoplasm. The ductules are exceedingly long and delicate, measuring in some cases .125 mm. or more in length. Those from the dorsalmost cells form an axis, about which the remaining cells are arranged (Fig. 11, *ag*). The groups of ductules (Fig. 11, *d*) from the several glands converge toward the ventral side of the lower lip, where they break up, and are distributed singly over the surface and margin of the lip.

Along the margins of both lips and within the mouth on the lower lip, small groups of slender gland cells open. During life these have a pale rose color and impart a decided tint to this region.

The functions of these two sets of head glands have not been certainly determined; but the habits of the animal suggest that they secrete a sticky fluid used either to aid the lips as adhesive organs, or to attach the cocoons, or both.

Glands similar to those described by Dorner, and more fully by Voigt, in Branchiobdella, are well developed in this species in relation to the posterior sucker (Fig. 5, *ag*). The glandular masses, which largely fill the tenth and eleventh and part of the ninth somites, are pyriform, or aggregations of several pyriform groups. Large, granular, lightly staining cell bodies give rise to long slender ductules, which, first united into fascicles, break up into smaller and smaller groups, and are finally distributed singly on all parts of the surface of the acetabulum. This arrangement is beautifully shown in living specimens. The ductules are filled with rounded granules, which may be forced from their mouths in living worms by pressure. The granules will emerge in strings, absorb water, swell, and run together in a very short time, forming a homogeneous mucus.

Of all the numerous glands developed from the epidermis none are so remarkable as the great lateral mucous glands, whose clearness in living examples suggested the specific name for the species. Each of the post-cephalic somites, from the first to the ninth, inclusive, possesses a pair of these structures, which occupy, in the more anterior ones, almost the entire body-cavity of the major annuli, lateral to the heart, alimentary canal, and nerve cord (Fig. 7, *lg*). Of more or less spherical or broadly fusiform shape, they pass dorsally and ventrally into fascicles of ductules which perforate the body walls, and open on the surface between two circular muscle fibres (Figs. 1 and 7, *lg*). Occasionally, instead of a single gland, there are two pyriform ones, placed end to end and more or less united (Fig. 1, *lg8*), or the cells may have this grouping within a single gland. The external openings are seen in surface views as four series (two dorsal and two ventral) of clear sieve-like spots, in which the ends of the ductules appear as 10–15 clear polygonal areas in a stained meshwork (Figs. 6 and 7). The ductules have a terminal diameter of .002 mm.

The exceedingly large gland cells, which often have a diameter much exceeding that of the entire nerve-cord and ganglia, that is, about .05 mm., have an irregularly polyhedral shape; their broad bases being fitted together to form the surface of the gland, near which the nuclei lie; while internally they taper into the ductules which frequently traverse the entire length of the gland, and emerge with the fascicle at the opposite pole, often having a complete length of .1 mm. The cell protoplasm is faintly granular, and very transparent; and is very slightly, or not at all, affected by stains. Of all the stains which were used methyl green alone gave a decided color.

Biondi-Ehrlich readily differentiates between these and the adhesive glands of the acetabulum, which most resemble them, staining the former more blue, the latter more red. Alcoholic cochineal fails to stain the contents of these cells at all, while the adhesive glands are deeply colored. The cell-walls and nuclei, however, always stain deeply. The former are distinct, but delicate, sometimes tensely stretched, sometimes, notably in worms which have been inactive for a long time, wrinkled and flaccid. Most of the abundant glairy mucus which envelops the resting worm is secreted by these glands. In the quiescent condition of the worm the posterior sucker is firmly fixed, the head and anterior somites are coiled ventralward, about one and one-half turns, and the transparent mucous covering thrown out as a protection. As it leaves the ductules the secretion has an almost fibrous structure, which reminds one of a spider's thread as it leaves the spinnerets, but this soon disappears in the water.

The lateral glands probably represent the setigerous epithelium of the Enchytraeidae, *etc.*

Filling up the basal portion of the upper lip is a conspicuous gland, which may have a salivary function, and which differs in appearance from any of the glands yet described. It is developed from a tubular invagination of the oral epithelium, just in front of the upper jaw (Fig. 9, *sg*), and, in the adult consists of a single stratum of coarsely granular pyramidal cells, opening into a short tubular duct, which is somewhat eccentric in position, owing to the cells of the posterior wall having their growth restricted by crowding against the muscular jaw-pad. A slight median dorsal constriction divides the gland into two lobes. This gland is further remarkable from the presence of a muscular sheath, which extends as a delicate sheet from the dorsal region of the muscular jaw-pad, over its dorsal and anterior faces, to the oral epithelium. The sheath slips freely over the glandular epithelium and serves to elevate the lip; and, perhaps, also to aid the flow of secretion from the duct by pressure on its walls.

Glandular structures, developed especially by the epithelia of particular organs, will be described in their proper connection.

Muscular system. — The muscles of the body walls are disposed in two layers, the outer of circular, the inner of longitudinal fibres (Figs. 7 and 11). Both consist of elements of somewhat complex structure, which has been described by Voigt for Branchiobdella; those of this species differ but slightly from Voigt's description, though they are smaller than in any Discodrilid which I have examined, the circular fibres having a diameter of about .0075 mm., and the longitudinal of .0075-.015 mm.

Only a general account of the muscles can be presented here, as a complete description of their distribution and variations in the different regions of the body would require the space of a separate memoir.

The circular muscle fibres do not form a continuous layer in the walls of the body somites, but are scattered singly at regular intervals, encircling the body like hoops, of which there are from 12 to 16 per somite. As before described, they are closely associated with the epidermis, in which they are deeply imbedded; and thus divide it into alternating cellular and non-cellular zones. This relation is so intimate that it is more convenient, if less accurate, to speak of a musculo-epithelial layer, rather than of a muscular and an epidermal. This is the more so because of the wide inter-muscular spaces which separate the circular from the longitudinal muscle layers; and permit to each greater freedom of adjustment. These spaces exist principally in the major annuli of all the complete somites, and extend completely around the body, except where interrupted by the spermatheca and atrium, in the fifth and sixth somites, respectively. In contraction the skin (epidermis and circular muscles) rises freely all around in a prominent fold, like an arch, as seen in optical or actual section, of which the longitudinal muscles form the cord. In extension, the two layers approach and touch, obliterating for the time the space between. The spaces are in part occupied by the smaller skin and clitellar glands, by the terminal trunks of the nephridia, the nephridial vesicle, and portions of the ductules of the great lateral mucous glands, and are further, more or less, filled by a loose reticulum of connective tissue fibres and cells. The circular fibres (Figs. 2 and 4) consist of a more or less complete tube of a dense fibrillated (having longitudinal striae) protoplasm which bears on the internal side a bulging mass of granular protoplasm, in which the nucleus is imbedded; similar granular protoplasm fills the lumen of the cortical tube. Minute branches of the cortical substance communicate with neighboring fibres, and thus form an irregular muscular reticulum, in the meshes of which the groups of epidermal cells are included (Fig. 3). This is well shown in surface views of the skin stained in methylene blue.

The more powerful longitudinal muscle coat is continuous throughout the length of the body, and becomes, through branching and complex interlacing, much differentiated at both the anterior and posterior ends. In general, the fibres are arranged side by side in a single layer, or incompletely in two layers; in the latter case those of one layer show a tendency to slip between those of the other. Most of the fibres have a length equal to a complete somite; but they are so arranged that the ends of adjacent fibres do not coincide by a distance equal to the length of a minor annulus; that is, in any somite, alternate fibres, all around the body, extend for the entire length of that somite through both annuli, while the remaining fibres extend from the posterior limit of the major annulus to the anterior limit of the minor annulus next anterior, thus breaking joints and materially increasing the strength and flexibility of the body walls. This arrangement is particularly striking in B. philadelphicus, in which the muscle fibres are much larger. Where fibres join end to end there is an irregular jagged interlocking, which looks like the line of a break across the grain of a board, and doubtless is to be explained on the same principles. The fibres have a structure similar to that of the circular muscles, but are exceedingly variable in the relative amount and arrangement of striated and granular substance. Some exhibit a complete cortical layer with radiating longitudinal markings, within which, as a medullary portion, the granular protoplasm is confined with the nucleus; others show a large mass of granular protoplasm, with the striated substance variously arranged, and perhaps limited to two small bands. Muscle fibres of the former type, but with the addition of an external granular mass, in which the nucleus is imbedded, about the middle of their lengths, are most frequently met with. Figs. 7, 8, and 11 show a few examples.

The inter-segmental septa are composed of more or less parallel dorso-ventral muscles, which form thin sheets, arising by one or two roots, from the ends of the longitudinal fibres. Where best developed the component fibres are bound together by cross-slips, much as are the circular body muscles. Septa are aborted between the first four somites, which freely communicate; but remnants remain as a few delicate slips which guy the alimentary tract to the body walls. They are well developed between the sexual somites.

The musculature of the posterior sucker is complex, and well adapted to secure strength and mobility. The circular muscles undergo little change; but the longitudinal split up, by the branching of individual fibres, into a set which are the direct continuation of the body longitudinal fibres, a second set which pass dorso-ventrally across the body cavity, a third which radiate to the margins of the disc, and, lastly, a highly branched set which have become slightly displaced at their posterior ends, right or left from their original longitudinal direction, and consequently pass with a slight spiral turn from the body walls to the periphery of the sucker, where they cross and interlace with their fellows having an opposite displacement.

Alimentary canal.—The digestive tract is distinguishable into oral, pharyngeal, œsophageal, intestinal, and anal regions.

The mouth has an extreme anterior position between the very mobile lips into which the peristomial annulus is divided. The dorsal lip is slightly the longer, and, projecting somewhat, gives to the mouth a slightly ventral aspect (Fig. 9). Labial papillae, so well developed in B. philadelphicus and in Branchiobdella, are absent, a few faint ridges indicating a slight tendency toward their development. Sensory hairs are also absent. Circular muscle fibres continue unchanged into the lips to the oral invagination; while the longitudinal muscles partly continue, but mainly break up into delicate dorso-ventral and radiating fibres, which traverse the internal cavity of the lips and constitute the chief musculature of these versatile structures. The lips are bounded posteriorly by the muscular jaw pads (Fig. 9, *dm*, *vm*).

Numerous single and small aggregations of unicellular glands are developed from the epidermis of the margins and internal surfaces of the lips. Such are especially numerous on the inner surface of the ventral lip just anterior to the jaw (Fig. 9, *og*). In a similar position on the dorsal lip is the supposed salivary gland, *sg*.

Immediately posterior to these structures are slit-like dorsal and ventral infoldings of the epidermis and cuticle, bounded behind by a thickened epidermal pad. On the posterior walls of these invaginated pockets, and on the epidermal prominences which follow, the jaws are molded. The cuticle of the invagination gives attachment to the protractor muscles of the jaws (Fig. 9, *dpm* and *vpm*), which are dorso-ventral fibres derived from the anterior face of the muscular jaw pads, in addition to which the ventral jaw possesses, as an accessory protractor, a pair of muscle fibres which arise from the apex of the muscular ridge into which the jaw pad rises, and, curving around an isolated fibre posterior to the mass of the pad, insert into the posterior limb of the jaw, on which they exert a dorsal traction, and consequently move the point of the tooth forward (Fig. 9). The retractor muscles are, particularly in the case of the dorsal jaw, an extremely large and powerful pair of fibres, which spring from the longitudinal muscular coat in the region of the first cephalic constriction, and pass obliquely forward to insert, in the case of the upper jaw, directly on the posterior limb of the jaw plate, and of the lower, into the epidermis and cuticle immediately behind the jaw (Fig. 9, *drm* [the anterior index line] and *vrm*).

The pad on which the jaws are supported is a powerful muscular apparatus formed of two (a dorsal and a ventral) half disks, each of which consists of four or five semi-circular or semi-lunar muscle fibres piled upon and embracing one another, and meeting those of the opposing half disk in a transverse line (Figs. 9 and 10, *dm* and *vm*). This is set transversely in the head at the beginning of the pharynx, and extends from the walls of the latter on all sides nearly to the external muscle layers of the head, to which it is bound by numerous radiating fibres (Fig. 10). A few dorso-ventral fibres cover the anterior and posterior faces of both plates. The circular fibres taper more or less from a nucleated middle toward both ends.

The mechanism of the jaws is seen to be powerful and efficient. The muscular plates, with their radiating fibres, regulate the distance between the two jaws, approximating or separating them as the circular or radial fibres contract in turn. The circular muscles seem sufficiently powerful to bring the jaws together with crushing force. The protractor muscles carry the jaws forward (with a rotary or rocking movement on the muscular pads) against an object of attack, the lower jaw acting with its teeth as a hook, while the powerful retractor muscles of the upper jaw bring its toothed blade with a shearing motion between the ventral teeth. Thus is constituted an efficient pruning apparatus, the chief purpose of which is, I believe, the clipping off of branchial filaments of the crayfish host, from which the blood is then drawn. They are probably also used for mowing down the colonial infusorians which cluster along the borders of the branchial chamber, and remains of which are frequently seen with diatoms, *etc.*, mixed with crayfish blood in the stomachs of worms examined.

The jaws mark the beginning of the pharyngeal region, which extends to the œsophagus in the anterior part of the first post-cephalic somite (Fig. 9). The region is distinguished by the great development of muscular tissue, and doubtless functions in the capacity of a suction bulb to increase the flow of blood from the wounded tissues of the host. The structure is similar throughout. A delicate cuticle lines its lumen, thinning out and disappearing where the transition from pharyngeal to œsophageal regions takes place. The epithelium is characteristic. As has been described above, cell boundaries are seldom clearly distinguishable, but the deeply staining protoplasm, with its contained nuclei, is crowded, with the exception of a delicate continuous layer, from its normal position at the surface, into irregular processes, which fit plug-like between the ends of the radial muscle fibres (Fig. 11, *ep*). If the epithelium could be completely isolated, it would present somewhat the appearance, without the regularity of pattern, of those ingenious rubber change mats which are in such frequent use on the show-cases of our stores.

Immediately external to the epithelium and highly developed is a continuous layer of circular muscles. The fibres have a very regular arrangement (Fig. 9, *ep*), are completely tubular, and increase in size toward the posterior end of the head, where they pile up into several layers and pass into the posterior cephalic septum, behind which they rapidly diminish into the delicate muscular coat of the œsophagus.

Radiating on all sides from the pharyngeal walls, traversing the head cavity and passing into its outer walls, are numerous large isolated muscle fibres (Figs. 9 and 11, *vm*). These originate externally from the longitudinal muscles, become somewhat constricted within the head cavity, and break up at their inner ends into numerous branches which spread and straddle the circular fibres, passing between them and penetrating the pharyngeal epithelium as described above. They are among the largest muscular fibres of the body, reaching a diameter of .025 mm. The central granular protoplasm is well marked, and contains a conspicuous nucleus, which may, however, lie on the exterior of the fibrillated protoplasm (Fig. 11, *rm'*). A pair of small, berry-shaped glands are attached, one on each side, to the lateral angles of the pharynx, just behind the jaw pads. They are partially indicated in Fig. 10, *g*.

The œsophagus is short, and its posterior limit rather ill defined. It is characterized by a sudden diminution of muscular tissue in the walls of the digestive tract, which takes place after penetrating the posterior cephalic septum and entering the first body somite, by a change in the character of its lining epithelium, and by the absence of chloragogue cells, which distinguish the intestine. The alimentary canal begins to increase in diameter within the body segments, and exhibits a slight sacculation in the second. In this region the lining epithelium is a single stratum of columnar cells, with freely rounded and often bulbous, projecting ends (Fig. 7, *oe*). No cuticle nor cilia have been detected in this region. The muscular coat of the œsophagus is principally made up of thin, transparent, non-granular fibres, forming a sheet which blends with each successive muscular septum, and is continuous without much change throughout the remainder of the alimentary tract. Circular muscles are distinguished as delicate rings on the inner face of the longitudinal sheet, but become much more conspicuous at the septal constrictions, where they derive additional fibres from the septa themselves.

The modification of the peritoneum to form chloragogue cells begins in the third or second somite, behind which the intestine is enveloped in a continuous layer to the seventh somite, where they are absent (or sometimes sparingly scattered among the peritoneal cells by which they are replaced), but reappear in the eighth and ninth somites (Figs. 5, 12, 13, and 15). In surface views of fresh material the chloragogue cells appear as a mosaic of large polygonal cells, with straight closely fitted edges, possessing a clear central nucleus, and cytoplasm of a greenish brown color, due to the presence of numerous large granules and minute globules. In sections they appear more or less flattened, or prominently bulging, according to their position and the degree of contraction of the intestine. In the region of the dorsal blood vessel they become elongated and arch over its walls. From their flattened or concave bases protoplasmic filaments and columns arise, which cross the peri-enteric sinus and bind the chloragogue cells and the epithelium more firmly together. By the increase of such strands in size and number the sinus is broken up anteriorly and posteriorly into plexuses. The granules with which the protoplasm is filled are stained deeply by most dyes; and the clear globules above mentioned blacken with osmic acid, while unaffected by ordinary stains, and dissolve in chloroform, *etc.*, appearing in sections as spaces. Their evident fatty nature leads me to regard the chloragogue cells as absorptive, while, on the other hand, their relation to the peritoneal corpuscles renders an excretory function probable. There seems, then, little choice between the two opposing views which have been brought forward, both probably being in part correct.

In the seventh or ovarian somite the absence of chloragogue cells (Fig. 15) permits the maturing ova to come into close contact with the walls of the blood sinus, which they envelop — a nutritive arrangement of importance. True chloragogue cells are again absent in the tenth segment on the rectum, which is covered by a layer of cubical peritoneal cells (Fig. 5). In the region of the anus circular muscle fibres increase to form a sphincter.

The epithelium of the intestine presents the same general characters as that of the œsophagus, but becomes more flattened (Fig. 12 and 13), especially in the saccular enlargements, while at the constrictions the elongated cells project into the lumen to form valve-like outgrowths (Figs. 5 and 13). It is ciliated only in the posterior part (Fig. 5).

Vascular system. — The vascular system differs in no important respect from the description given of Branchiobdella by Dorner and amended by Voigt. The peri-enteric blood sinus, to which Voigt first specially called attention in Branchiobdella, is highly developed in the present species, in which it exists as a continuous space between the muscular and epithelial coats of the intestine, extending from the third to the eighth somites inclusive, and breaking up at each end into a system of passages and lacunae having a retiform arrangement (Fig. 1). The sinus has an average depth of .005 mm.; and is without true walls other than the intestinal coats between which it lies. It is crossed by numerous protoplasmic strands and columns which bind its walls together, and remind one of the stalactites and columns of a limestone cave. These become larger and more frequent toward the ends of the sinus, which they finally interrupt so much as to convert it into the terminal plexuses mentioned. In Fig. 5, drawn from a specimen in which the sinus continued complete even into the ninth somite, these strands are well shown owing to the absence of any considerable quantity of blood, which often stains deeply and obscures not only the strands but the muscular coat as well. Enlarged chambers exist here and there in the course of the sinus; and continuous enlargements extend along the dorsal and ventral regions. The ventral or sub-intestinal enlargement remains throughout its entire length strictly a part of the sinus, with which it is in continuous communication; but the dorsal one, which has a similar relation posteriorly, begins in the fifth somite to have the character of a distinct vessel, which has more or less complete walls and rises above the level of the sinus, from which it may be entirely free for a short distance, but again open into it through a cleft (Fig. 12). Perforating the septum 4–5, from which its muscular walls receive accessions, it becomes a distinct muscular tube, still imbedded amongst the chloragogue cells, and, increasing in diameter, passes obliquely down the right side of the intestine, with which it loses all connection in the third somite, and becomes a regularly pulsatile tube — the so-called heart. The heart thus formed is thrown into a conspicuous loop, which accommodates itself to changes in the animal's length. It lies to the right of the œsophagus, and in the first somite rises once more to a dorsal position and gives off the fifth pair of vascular arches; anterior to which it continues into the head as the dorsal trunk.

At the place of origin of the heart from the blood sinus certain chloragogue cells extend into its lumen, and give rise to a remarkable chain of valve cells, which retain all of the visible characters of the chloragogue cells. This rod is chiefly confined to the ventral wall of the heart, to which it is more or less closely bound. The inter-cellular space described by Voigt is well marked in this species, and may be seen to increase and decrease in size with the expansion and contraction of the heart. Occasionally in sections (Fig. 14, *b*) the cells form only a thin wall around a conspicuous lumen. In some cases also there are indications of a special muscular layer surrounding the cells (Fig. 14). They are also attached here and there to the walls of the heart by delicate threads (Fig. 7, *h*). The rod is continuous throughout the greater part of the heart and may even extend into the dorsal vessel of the head (Fig. 9). Well fitted to serve as valves, the peculiar arrangement of the cells permits them to act also in the direct propulsion of the blood. The cells present more flattened surfaces anteriorly, and more sloping ones behind, and swinging forward as the wave of contraction passes along the heart walls, push the blood along, and then return without offering much resistance, and complete another oscillation before coming to rest. As the wave of contraction passes forward they close the lumen of the heart more effectually than would be possible for the muscular walls alone, and add greatly to the efficiency of the organ.

The dorsal vessel of the head is very much smaller than the heart; and as the posterior portion is also elastic and somewhat contractile, the flow of blood is doubtless nearly or quite continuous, although the heart contracts intermittently. From it three pairs of conspicuous but delicate lateral trunks arise, corresponding to the three posterior cephalic annuli, and wind among the muscles around the pharynx to join the sub-neural vessel. The most anterior of these three blood arches is closely associated with the circum-œsophageal nerve connective. Finally the dorsal vessel terminates, after passing beneath the supra-œsophageal ganglion, in a pair of trunks which arch through the lips close to the salivary gland, and meet ventrally to constitute the supra-neural blood vessel (Figs. 1 and 17), which is soon increased by the accession of the second, third, and fourth pairs of cephalic blood arches (Fig. 16), and, in the first body somite, by the fifth pair of arches. Throughout its entire length the supra-neural vessel lies in contact with the dorsal side of the nerve cord, and passes between the ganglia of each pair in a deep groove (Figs. 1, 7, 11, *etc.*). In the seventh somite it gives off a pair of large ovarian vascular arches, which empty into the dorsal enlargement of the peri-enteric sinus (Fig. 1). The supra-neural vessel terminates in the tenth somite in a pair of large trunks, which arch around the intestine, and pass forward to empty into the dorsal region of the peri-enteric sinus, thus forming the beginning of the dorsal enlargement, which here receives the dorsal ends of the plexus of blood passages (Figs. 1 and 5). Of the seven pairs of lateral arches mentioned, a labial and three cephalic pairs, in the pharyngeal region, arise from the anterior prolongation of the heart; an œsophageal pair, which owing to their great length are often looped into the succeeding somite, arise from the anterior end of the heart itself; a large pair of ovarian arches, which are more or less imbedded in the maturing ova, lie in the posterior part of the seventh somite; and the seventh pair, which are the largest of all, posteriorly connect the supra-neural vessel with the peri-enteric sinus. The walls of the supra-neural and lateral vessels are very delicate and non-contractile. At wide intervals, nuclei, which resemble those of the peritoneal cells, may be detected, but I have found no traces of cell boundaries.

Nervous system. — The nervous system does not differ in any important particular from the description given by Dorner for Branchiobdella. It consists of a pair of supra-œsophageal ganglia lying just posterior to the dorsal jaw pad. The two ganglia of this pair are united across the median line by a cord of nerve cells and a fibrous commissure; and each bears well marked posterior lobes, which are themselves divided into larger external and smaller internal parts, and are connected with the main ganglion by three strands of nervous matter (Fig. 17). The vascular arches of the second pair pass along the groove between the anterior and posterior divisions of the ganglia, and follow the connectives about to be described. The circum-œsophageal connectives are thick strands of nerve fibres, with a partial covering of nerve cells which extend from the ganglia particularly along their posterior and anterior faces. They pass around the pharynx, and, just before meeting on the ventral side, each bears a bi-lobed pedicled ganglion (Figs. 1 and 16), and after uniting to form the ventral nerve cord, two succeeding pairs of similar but larger ganglia; making in all four pairs of double ganglia within the limits of the head (Figs. 1 and 16). The nerve cord, which consists of two distinct halves throughout its length, enlarges at the ganglia and shrinks in the inter-ganglionic intervals. Numerous nerve fibres arise from the circum-œsophageal connectives and the superior ganglia, and pass to the peristomial region. In B. philadelphicus these can be readily traced by the use of methylene blue to the circum-oral hairs, and especially to the oral papillae.

In the post-cephalic somites a ventral chain of eight pairs of bi-lobed ganglia is succeeded by a posterior ganglionic mass, representing three pairs of coalesced ganglia which successively diminish in size toward the posterior end (Fig. 1). The anterior eight are situated in the major annuli of the corresponding number of somites. They are of equal size and similar form ; the posterior lobe of each being slightly smaller than the anterior. The fifth and sixth are slightly displaced to the right of the middle line, respectively by the spermatheca and the atrium, especially the sixth, which is also turned on edge and bound to the muscular wall of the copulatory bursa. Dorsally all of these ganglia rise above the level of the nerve cord (Figs. 7, 11, and 18) to which they are broadly attached ; forming a series of grooves in which the supra-neural vessel is accommodated. Three pairs of nerves spring from the region of each pair of ganglia, one from each end and one from the transverse constriction (Fig. 18). These supply the body walls, and are readily traced between the two layers of muscles, splitting up as they proceed. The first and second nerves supply the major annulus alone, the third (posterior) divides, one branch passing to the major, the other to the minor annulus. The posterior mass is related to the caudal concentration of somites for the support of the sucker, and lies posterior to the septum 8–9. It does not differ in minute structure from those anterior. The anterior ganglion of the mass is larger and the posterior smaller than the isolated pairs of ganglia. Several lateral nerves have their origin here, and the cord terminates in a brush of smaller nerves which supply the numerous glands and muscles of the region. Long narrow fissures appear along the middle line of the nerve cord at intervals for its entire length, and frequently penetrate completely through, separating the two halves of the cord.

A thin sheath which encloses the nerve cord for its entire length and includes the supra-neural vessel, appears to be muscular.

Besides the smaller ganglion cells which make up the bulk of all of the ganglia, each ganglion possesses a small basal group of larger ones (Fig. 18). No visceral nervous system has been detected ; nor any of the large isolated ganglion cells figured by Voigt in connection with the acetabular glands.

Reproductive system. — The reproductive organs of Bdellodrilus differ in certain important respects from those of Branchiobdella, as described by Dorner, Keferstein, Voigt, Vejdovsdy, *etc.;* but nevertheless there is a close general resemblance between the two. Resembling its allies, Bdellodrilus is hermaphroditic, and possesses accessory sexual structures admirably fitted to the process of reciprocal fertilization, which, no doubt, occurs during copulation. The general arrangement of the reproductive organs is shown in Fig. 1.

The male organs occupy the greater part of the peri-enteric cavities of somites five and six. They consist of two pairs of testes, and two pairs of vasa deferentia, having a common opening to the exterior by means of a complex unpaired atrium, which is differentiated into a glandular sperm sac, a muscular sperm sac, an eversible penis, and a muscular copulatory bursa, with its associated glands. The testes proper can be distinguished satisfactorily only in the young, in which, if examined shortly after hatching (or after removal from the cocoon just previous to that event), they are easily detected in entire worms or in sections as small groups of rounded nucleated cells, attached near the floor of the body on each side of the posterior faces of septa 4–5 and 5–6. Their origin from the peritoneal lining of the cœlom is evident upon the examination of longitudinal sections of several successive stages of development. The first steps in the development of spermatozoa begin before the worm has nearly reached full size, and proceed continuously; the various stages floating freely in the cœlom, in which they complete their development. In the mature worm the cavities of the fifth and sixth post-cephalic somites are filled with spermatozoa in various stages of development, while the testes proper have become much reduced and inconspicuous. The details of this process have been admirably worked out and described by Voigt; and it need only be added that what observations the writer has made are in accordance with his account.

The male efferent ducts (Figs 1, 19, and 20) correspond in number to the testes, and their mouths open into the same somites. The mouths of the anterior pair lie far forward in somite five, both being usually displaced to the left side by the spermatheca, which occupies the right of the same somite. Penetrating the septum 5–6 close together near its ventral attachment, they unite, and proceed as an unpaired duct to the copulatory bursa, to the anterior walls of which it is attached, and then turns sharply upward to empty into the middle of the glandular sperm reservoir. The posterior pair, lying entirely in somite six, are shorter and more symmetrically arranged. Their free ends are attached to the anterior face of the septum 6–7, from which their mouths turn forward. The common duct into which they unite is slightly attached to the bursa, and empties into the sperm sac at the same place as the anterior (Fig. 19). These vasa deferentia are rather broad thick-walled tubes with narrow lumens. They are lined by a naked cubical epithelium, which becomes more columnar and acquires cilia a short distance from the free end, which presents no funnel-like expansion. (In a single preparation, out of a great many examined, all four vasa deferentia possessed expanded mouths.) The epithelium is covered by an outer layer of narrow elongated cells, which are placed transversely, and form a complete investment around the duct, except of the ciliated cells, which extend freely beyond this covering (Fig. 25). These cells are undoubtedly muscular, and have the same structure as the larger muscle fibres which similarly invest the walls of the spermatheca (Fig. 21). In living animals subjected to pressure a faint and irregular wave of contraction may sometimes be seen to travel along the walls of a vas deferens toward the atrium; and such peristalsis doubtless serves to impel the spermatozoa along the non-ciliated passages.

The atrium (Figs. 19 and 20) or enlarged terminal portion of the male efferent apparatus, is divided into two distinct portions, the internal glandular spermatic vesicle, which belongs to the vasa deferentia, and serves to collect and retain the spermatozoa; and a prominent muscular-walled region which functions as a copulatory organ, and is derived from an invagination of the body walls. The former (Figs. 19 and 20, *sv*) is a short curved sac, somewhat enlarged at the free end and tapering toward the other, where it suddenly contracts in diameter before emptying into the anterior side of the enlarged inner end (muscular sperm sac) of the penis. The glandular sperm sac lies in contact with the anterior side of the penis sheath, where it is held by the vasa deferentia (Fig. 19). At about the middle of its length it presents a slight ventral enlargement which receives the vasa deferentia, beyond which it curves abruptly upward. The thick glandular walls are made up principally of deeply-staining columnar or irregularly pyramidal cells, with distinct basal nuclei, and reticulated granular protoplasm (Figs. 22 and 23). At the place of communication with the muscular sperm sac these cells perforate the muscular coat of the latter, and become continuous with its lining epithelium (Fig. 23). No cilia are present in the sperm sac.

The copulatory region of the atrium is formed by a single invagination of the entire thickness of the body wall; the epidermis becoming the epithelial lining, and the longitudinal and circular muscle coats, respectively, the longitudinal and circular muscle coats of the atrium. Proximally the invagination becomes expanded into a conspicuous sub-spherical copulatory bursa (Figs. 19 and 20), the posterior dorsal portion of which is continued into the sub-cylindrical penis sheath (Fig. 19). The thick muscular walls of the bursa are principally derived from the longitudinal muscles of the body. These continue their longitudinal direction over the bursa and penis sheath, increasing in thickness on the anterior wall of the former, while on the latter only a single layer of closely appressed fibres is developed. They cease entirely at a constriction which marks the upper end of the penis and the beginning of the muscular sperm sac (Figs. 19 and 20). At the point where the bursa passes into the penis sheath a reflection of a portion of the longitudinal fibres (which pushes the epithelium before it) into the cavity of the former, gives rise to the basal portion of the penis, which, when retracted, projects as a conical process downward and forward into a space between the bursal glands (Figs. 19, 20, and 26).

The circular muscle fibres become in the walls of the bursa quite distinct from the epithelium and more closely associated with the longitudinal muscles. Around the mouth of the bursa they form a sphincter, but elsewhere a thinner layer one fibre deep. This is interrupted in the upper part of the copulatory bursa by the enormous enlargement of two lateral groups of epithelial cells to form the bursal glands, which push between the two muscular layers and occupy what corresponds to the spaces between the longitudinal and circular muscles of the body walls, bulging the side walls of the bursa outwards, so that the transverse diameter is fully one-half greater than the antero-posterior (Figs. 19, 20, 24, and 26). The circular muscles thus lie entirely within the bursal glands, between these and the lumen of the bursa.

In the penis sheath (Figs. 19 and 20) the circular fibres become still further distinct from the epithelium, and closely connected with the longitudinal muscle coat; leaving a nearly empty space all around, between the epithelium and the circular muscles. Numerous small muscular slips, from the circular fibres, traverse this sub-epithelial space and insert among the epithelial cells. For the sake of clearness these have been omitted in the partly diagrammatic Figs. 19 and 20. These fibrils, which must be capable of great extension, are an important factor in the eversion and retraction of the penis. At the constriction of the penis sheath above mentioned the sub-epithelial space ceases (Figs. 19 and 20), and the circular muscles come in direct contact once more with the epithelial cells. They extend together beyond the limit of the longitudinal muscles, and expanding, form a prominent vesicle (Figs. 19 and 20 *sv'*) which receives the glandular sperm sac, and into the cavity of which the lumen of the penis expands. The muscle fibres of the atrium (Figs. 24 and 26) possess rather elongated nuclei, and differ somewhat in minute structure from those of the body walls, being rather a transition form between these and such as cover the spermatheca. The fusiform shape which Fig. 26 shows is due to oblique section.

The epithelial portion of the invagination is derived from a cellular zone of the epidermis, and undergoes no change throughout the greater part of the bursa, except in the dorsal region, where a pair of conspicuous glands are developed, one on each side of the space in which the end of the penis lies (Figs. 20, 24, and 26, *g*). The gland cells are arranged in an almost spherical group around a deep hilum, or sinus, which serves as a duct, and opens directly into the cavity of the bursa. The cells are pyramidal, with broad, deeply staining bases containing the nuclei; and elongated necks which are highly granular, but stain less deeply, and converge toward the sinus, in which the cuticle is interrupted (Fig. 26). The presence of these glands complicates the shape of the cavity of the bursa. Ventrally (below the glands) it is transversely extended, and, as the glands stand out from the posterior wall, antero-posteriorly constricted; higher up (between the glands) it is narrowed in its transverse dimension, and extended antero-posteriorly; dorsally it expands, but is much encroached upon by the projecting end of the penis. Figs. 19, 20, and 24 will make this clear.

Over the free projecting end of the penis the epithelium is, of course, reflected, and then continues with its cuticular covering as the lining and eversible portion of that organ. Here the cells become rather smaller, but regain their size in the muscular sperm sac, into which the cuticle also continues. This penis epithelium is, as it were, much too long for its muscular sheath, and is consequently thrown into folds or slightly spiral coils within the sub-epithelial space (Figs. 19 and 20, *pe*), the narrow lumen appearing as a conspicuous wavy double contour. In protrusion these waves are straightened; partly pulled out by the contraction of the minute muscular fibrils, partly squeezed out by the pressure of the circular muscle coat, and partly by the shortening of the whole organ, owing to the contraction of the longitudinal muscles. By the combined action of these forces the epithelium is everted, and projects from the external opening of the bursa as a double-walled tube, slightly bulbous at its free end, and covered with a smooth cuticle. Whether or not the bursa itself is everted naturally in this species is a question. By careful application of pressure while under the microscope I have been able to force it through the external opening; but it always carries the sixth nerve ganglion with it under such circumstances;

and, although naturally everted penes are not difficult to observe, the bursa is never displaced. The everted penis in such cases is quite long enough to be functionally useful. In B. philadelphicus, on the other hand, the penis and its sheath are united into a solid piece, incapable of eversion, and here the whole bursa, which has quite a different structure, is everted naturally and carries the short projecting end of the penis with it. The inner surface of the bursa is smooth in B. illuminatus, and shows no trace of the elongated and more or less branched papillae which are present in certain other species.

The ovaries (Fig. 1) consist of a pair of cell masses attached one on each side to the septum 6–7, and hanging into the cœlom of the seventh somite. In immature individuals they have the arrangement described by Voigt for Branchiobdella, but are more slender, and are borne on longer muscular pedicles. In the mature worm the ovaries have become much more bulky and of irregular shape (Fig. 1). Their mass is made up of young ova (Fig. 27) of nearly uniform size. The immature ova are spherical, with a large, clear nucleus and distinct nucleolus. A transparent stroma in which the ova are imbedded appears to be present, and the ova themselves are arranged in irregular rows, showing the manner in which they have proliferated and pushed out from the germinal epithelium. Among the ova of the peripheral part of the mass a few enlarged ones in the early stages of maturation are always present, and two or three large irregular ones nearing maturity. The latter have usually broken loose from the ovary, and, as irregular masses, conform to the shape of the perivisceral cavity, which they largely fill, closely enveloping the intestine. A clear nucleus may always be detected in living examples, in which the white opaque ova are very conspicuous. In such ova the nuclei have become very much enlarged and somewhat vesicular. The entire cytoplasm is filled with minute rounded yolk granules (Fig. 28, *o*), among which a few deeply staining specks are scattered. During the period of maturation the ova appear to receive nourishment directly from the peri-enteric blood sinus, with the thin wall of which they lie directly in contact. The pair of vascular arches, around which the ova frequently wrap, serve the same purpose. Large coarsely granular masses, which Voigt regards as fatty degenerated ova, are frequently present, and appear to be absorbed by the maturing ova.

No free oviducts are present, the mature ova escaping by a pair of simple ovipores (Fig. 28), which are ridiculously small as compared to the mature ova, though capable of considerable distention, and perforate the body walls in the constriction between the major and minor annuli of the seventh somite, each in the ventral octant of its respective side. The lining epithelium resembles that of the copulatory bursa, *etc.*, and spreads out on all sides of the internal aperture as a flaring lip (Fig. 28). Cilia are wanting, and the ova are extruded by pressure of the body muscles, a process which may be successfully simulated by artificial means. The ova are very plastic, but at once assume a rounded form in the water. Fig. 28 is taken from a preparation of B. philadelphicus, as the section passed through a more favorable plane for representation than any of B. illuminatus. No essential difference, however, is observable between the two species. Note, however, the much larger size of the longitudinal muscle fibres and the smaller size of the epidermal nuclei in B. philadelphicus. Part of an ovum is shown at *a* lying opposite to the mouth of the ovipore.

As in Branchiobdella, the spermatheca is unpaired; but in the present species has a very characteristic form (Figs. 1 and 29). The proximal portion opening on the ventral surface of the fifth somite is sub-cylindrical, but expanded just within the mouth by large anterior and posterior glands. Dorsally by the side of the intestine it splits into a pair of clavate sacs, of which the external (Fig. 29, *o*) is the larger, and is often thrown into a coil. The internal slightly smaller sac (*i*) has usually the appearance of a lateral branch, being more displaced from the axis of the organ than the outer. The lining epithelium has also a more glandular appearance (Fig. 30). In living animals both divisions show slight terminal enlargements, and, owing to contractions of the muscular coat, irregularities in diameter.

Around the mouth of the spermatheca the epidermal cells become more columnar, producing the slight swelling of the lips (Fig. 29, *ep*). Immediately within the mouth the transparent (almost vitreous-appearing) ductules of the spermathecal glands empty. These glands are hemispherical aggregations of small pyramidal gland cells (Fig. 29).

Above this point the epithelium maintains a nearly uniform character, becoming somewhat deeper and more glandular in the smaller of the two branches. The cells are large and deep, and have polygonal basal outlines; and good preparations show a distinct division of the protoplasm into a basal more opaque and an apical (next to the lumen) clear zone (Fig. 30), the free ends of the cells being often very indistinctly bounded. The large central nucleus exhibits a distinct chromatin network (Fig. 30).

Two layers of muscular fibres invest the undivided portion. Of these the outer longitudinal extends with a slight twist as a thin transparent sheet a single fibre deep, over the glands nearly to the point of bifurcation, where it fades out (Figs. 29 and 32). Each fibre possesses an ellipsoidal nucleus having its longer diameter directed longitudinally; and clear, almost homogeneous, but deeply staining cytoplasm (Fig. 32). The powerful circular layer is more extensively developed. Beginning above the glands, it forms a continuous layer of remarkable encircling fibres, mostly arranged transversely to the long diameter of the organ, but usually more or less spirally on the blind end of the smaller division, an arrangement which is sometimes even more regular and conspicuous than in the example figured (Fig. 29). Owing to the thick rounded form of these cells (Fig. 30), and the somewhat irregular manner of their disposition, the surface of the organ is thrown into rounded ridges (Fig. 30), which, during life, are rendered still more prominent by the irregular contraction of the muscle fibres. The fibres of the circular muscle layer resemble those of the longitudinal layer in structure and appearance; the cytoplasm is even more homogeneous and clear (Fig. 32). Many of the fibres pass almost entirely around the spermathecal walls. They taper toward the ends and overlap one another, as shown in Figs. 29 and 32.

Excretory system. — The number of nephridia is reduced, as in Branchiobdella (Dorner, Vejdovsky, *etc.*), to two pairs. Of these, one pair is located symmetrically entirely within the eighth somite (may communicate with the seventh), opening to the exterior by small non-pulsating vesicles on the dorsal surface of the body between the eighth and ninth somites. In structure they are similar to the anterior ones (Fig. 34).

The anterior pair alternate in position, one occupying the body cavity to the left of the alimentary canal in the second and third somites, and extending forward to the right side of the first; the other lying mostly within the fourth somite, of which its most conspicuous portion occupies the right side. The cellular masses into which the nephridial tubules plunge (compare Dorner) are darkly colored and conspicuous in the living animal, that belonging to the anterior nephridium being located on the left side of the third somite, that of the more posterior to the animal's right in the fourth somite.

The somewhat complicated course of the tubules has not been fully unravelled in detail, so that the present account will be confined to the statement of a few clearly ascertained facts. The anterior pair of nephridia have a common external opening through a median vesicle on the dorsum of the third major annulus. This is formed from an invagination of the epidermis, which lines it, and a covering of muscle fibres (Fig. 33). An internal proliferation of its lining cells forms a nearly complete valve-like diaphragm, which divides the interior into an anterior larger compartment opening to the exterior by a pore, and a posterior smaller one which receives the terminal portions of the nephridial tubules, and communicates with the anterior through an opening in the diaphragm. The terminal portions of the tubules, which are of large size, pass from the vesicle transversely around the body, one to the right, the other to the left, between the two muscular layers; and, entering the body cavity close to its floor, diminish decidedly in diameter (Fig. 35), and then pass into a long tubule which is arranged in a complicated series of long loops, which pass over and around the intestine, and, in the case of the left nephridium, reach far forward into the first somite, and, of the right nephridium, extend transversely across the intestine, in contact with the anterior face of the septum 4–5. The tubules of this region are more or less enveloped by greatly enlarged peritoneal cells, which enwrap the groups of tubules, and become more or less fused with their fellows into a continuous protoplasmic mass, though many stand out freely from this mass, and, in the living worm, are swept backward and forward with currents of the cœlomic fluid produced by the heart's pulsations, *etc.* Even in the mass of cells the boundaries are often perfectly evident, and the cells may even be widely separated (Figs. 36 and 37). Their central protoplasm is arranged in a coarse network, the meshes of which become smaller, and finally almost indistinguishable at the periphery. The nuclei are large and distinctly nucleolated (Figs. 36 and 37).

The tubules themselves, including the terminal portions quite to the point of union with the vesicle, are made up of tubular cells joined end to end in a continuous chain, with a continuous central lumen. This lumen exhibits slight irregularities in diameter, and may wind more or less from side to side within the substance of the cell. Where two cells are joined the lumen almost invariably develops two, three, or four short cæca (Fig. 35), which sometimes reach almost to the surface of the cell, and may run together more or less to form an irregular chamber. Midway between two of these nodal points the nucleus may always be seen lying close to the lumen. At the point where the tubule leaves the body cavity a curious arrangement of the lumen exists. Here there is developed either an irregular chamber partly divided by columns or islands of protoplasm, or else, and more frequently, an irregular branching and looping of the lumen, one form of which is shown in Fig. 35. The walls of the living tubules of this region exhibit evident radial striations passing as dark lines from the lumen to the external surface of the cells (Fig. 35). Sections across the four tubules, the irregular windings of which make up the greater part of the terminal loops of the nephridia, especially at points where their approximation enables us to readily compare their appearance, show a slight difference in the structure of their cell walls. In the case of one pair (the two limbs of a loop, Fig. 36, *n*), the protoplasm is more uniformly distributed, and the granules show a decided tendency to become arranged in lines radiating from the lumen, as seen also in living cells; while the protoplasm of the remaining pair (forming another loop) is more or less reticulated and less deeply stained (Fig. 36).

The system of simple tubules is partly concealed in the dark cellular mass mentioned above, where it becomes connected with a series of intra-cellular plexuses — not mere lateral branches of the main lumen, as Bourne has described in certain leeches, but a regular series of actual interruptions of the simple lumen.[1] The course of the tubules within this mass is very irregular and tortuous. Turning abruptly on itself at frequent and regular intervals, the tubule expands into irregularly rounded nodules of about three times the ordinary diameter. Within the highly granular protoplasm of these swellings the lumen breaks up into a complex system of irregularly branching and communicating canals, all of which converge at the opposite point of the nodule to empty into the next section of the simple tubule (Fig. 39), so that in this region there is a regular alternation of short lengths of simple ciliated canals and irregular plexuses of non-ciliate anastomising canals. The latter may be aptly compared to the communicating passages which termites excavate in the trunks of trees; but the capacity of the passages relatively to the amount of solid substance between and around them is less in the structure here described.

Nuclei are present both in the simple segments of the tubules and in the plexus cells (Figs. 38 and 39). Cilia are distributed throughout a considerable portion of the simple tubules, and in the simple canals connecting successive plexuses (Fig. 39); and are absent from plexus passages and in the terminal segment of the tubule (Fig. 35). No nephrostomes have yet been detected in this species; but Fig. 40 represents one of B. philadelphicus, which has nephridia of similar structure.

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[1] See also Eisen's paper on the remarkable nephro-plexuses of Deltania and Argilophilus which I have read since writing the above. *Mem. Cal. Acad. Sci.* Vol. II., No. 3. 1894.

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Our knowledge of the anatomy of the Discodrilidae has been contributed chiefly through the following papers, most of which are referred to in the text. The earlier papers, most of which are purely systematic, are listed in Dorner's paper.

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DESCRIPTIONS OF FIGURES.

Unless specially stated otherwise, all drawings have been made upon camera lucida tracings. With the exception of Figs. 28 and 40, which represent parts of B. philadelphicus, all figures are drawn from preparations of B. illuminatus.

EXPLANATION OF PLATE XXVIII.

FIG. 1. A diagram of the general anatomy of Bdellodrilus illuminatus showing the principal organs, enlarged about eighty diameters. The entire vascular system is colored; the principal trunks and the dorsal and ventral enlargements of the sinus being a darker, and the greater extent of the sinus a paler tint of the same color. The post-cephalic somites are numbered 1 to 11; the four annuli anterior to 1 constitute the head.

Alimentary canal. *P*, pharynx; *æ*, oesophagus; *S*, two of the stomachic enlargement; *a*, anus. In the seventh somite the intestine is hidden by the ovaries and maturing ova.

Vascular system. *H*, *H*, heart; va^{1-7}, the seven pairs of vascular arches, of which four are in the head, and one each in the 1st, 7th, and 9th post-cephalic somites; *sn*, *sn*, the supra-neural blood vessel; *pa*, the anterior, and *pp*, the posterior peri-enteric plexuses which terminate the sinus; *s*, sinus, the dorsal and ventral enlargements are indicated by their deeper color.

Nervous system. *sg*, principal, and sg^1, the accessory supra-oesophageal ganglion; *cc*, the circum oesophageal connective; cg^{1-3}, the three pairs of double ventral cephalic ganglia; g^{1-8}, the ganglia of the first eight post-cephalic somites; *gn*, the posterior ganglionic mass.

Reproductive organs. t^1 and t^2, testes, represented as they appear in the immature worm; vd^1 and vd^2, the anterior and posterior pairs of vasa deferentia; ♂, the male pore; *bm*, *bm*, the muscular walls of the copulatory bursa; *bg*, the bursal glands; *sv*, the glandular, and sv^1, the muscular sperm sac; *Pe*, penis; *Ov*, ovary; O_1, O_1, nearly mature ova; O^1, smaller, but developing ova; ♀, female pore; *sp*, sp^1, and sp^2, the undivided, the outer, and the inner divisions of the spermatheca, respectively.

General *nv*, the common vesicle of the anterior nephridia; *nt*, the terminal portion of the nephridial tubule of the right side; lg^{1-9}, lateral glands, dorsal and ventral points of outlet shown for all, complete glands outlined in somites 2, 4, and 8, the last a divided one.

FIG. 2. A transverse section of a portion of the epidermis from the dorsum of the 5th somite. Kleinenberg's haematoxylin. × 500. Cellular zone to the right, non-cellular to the left of the figure. *cc*, cuticle; *sl*, striated lamina; *ec*, groups of nucleated cells; *sa*, cleft or space in the protoplasm, *d*, *d*, dark column; *cm*, circular muscle fibres; *n*, nucleus.

FIG. 3. Tangential section through region of Fig. 2, lettering the same. × 500.

FIG. 4. Longitudinal section through a portion of the clitellum (dorsum of sixth somite). Alum cochineal. × 195. *c*, *c*, epidermal cells; *g*, *g*, glands; *lm*, longitudinal muscle fibres; *cm*, circular muscle fibres.

FIG. 5. Partial reconstruction, from camera drawings of successive longitudinal sections, of a median projection of the posterior end of the body. Alum cochineal. × 195. The body walls are shown in outline. *ag*, *ag*, acetabular glands; *d*, *d*, *d*, groups of ductules which are distributed in the hypodermis; g^8, eighth ganglion; *gn*, posterior ganglionic mass; *n*, terminal bundle of nerves; *cc*, chloragogue cells; *ec*, ciliated epithelium of intestine; *bs*, blood sinus; *a*, anus; va^7, terminal vascular arch.

FIG. 6. Diagram of a lateral gland, shown as though partly cut open to exhibit internal structure.

FIG. 7. Transverse section through the major annulus of the 1st somite. Borax carmine. × 195. *lg*, lateral glands; *gv*, *gv*, ventral, and *gd*, *gd*, dorsal openings of ductules; *h*, heart; *vc*, the internal chain of valve cells; *œ*, œsophagus; *nc*, nerve cord; *sn*, supra-neural blood vessel; *g*, ganglion; *va*, portion of fifth vascular arch; *lm*, longitudinal muscle fibres; *hy*, hypodermis.

FIG. 8. Cross-sections of four forms of longitudinal muscle fibres. Haem. × 500. 2d somite.

EXPLANATION OF PLATE XXIX.

FIG. 9. A reconstruction, from camera drawings, of a median plane projection of the head. *hy*, hypodermis; *og*, oral glands; *sg*, salivary (?) gland; *ag*, adhesive gland; *dj*, dorsal, and *vj*, ventral jaw; *dm*, dorsal, and *vm*, ventral muscular pads; *dpm*, dorsal, and *vpm*, ventral protractor muscles; *drm* (foremost index line) dorsal, and *vrm*, ventral retractor muscles; *lm*, longitudinal muscle fibres; *rm*, radial muscle fibres; *cm*, circular muscle fibres; *ep*, pharyngeal epithelium; *pc*, cuticle of pharynx; *sga*, supraœsophageal ganglion; *nc*, ventral nerve cord; g^1, first post-cephalic ganglion; *dv*, dorsal blood vessel; *sv*, supra-neural blood vessel.

FIG. 10. Transverse section of the head in the region of the jaws. Kleinenberg's haematoxylin. × 195. Lettering as in Fig. 9. *g*, *g*, pharyngeal glands.

FIG. 11. Transverse section through the middle region of the head of a larger individual than 9 and 10. Klein. haem. × 195. Lettering as in Figs. 9 and 10. *d*, *d*, groups of ductules passing from head glands to the lower lip; rm^1, a radial muscle fibre with granular protoplasm and nucleus external.

FIG. 12. A transverse section of the intestine in the 4th somite. Haem. × 195. *cc*, chloragogue cells; *m*, muscular coat; *bs*, blood sinus; *vbs*, ventral enlargement of the sinus; *hm*, muscular walls of the beginning of the heart; *vc*, valve cells; *s*, inter-cellular space; *pp*, peritoneal corpuscles.

FIG. 13. Longitudinal section of a portion of the intestine along the dorsal enlargement of the sinus (6th somite). Alum coch. × 195. The sinus is filled with deeply-stained blood fluid.

FIG. 14. Two transverse sections through the heart. Haem. × 230. *a* is seven sections anterior to *b* in the same series, and is much more contracted. *m*, muscular walls; *n*, muscle nucleus; *pn*, nucleus of peritoneal cell; *vc*, valve cells; *b*, their inter-cellular space.

FIG. 15. A transverse section across a ventral portion of the intestine in the 7th somite. Biondi-Ehrlich. × 500. *e*, ciliated epithelium; *s*, blood sinus; *vs*, its ventral enlargement; *m*, muscular coat; *p*, peritoneum.

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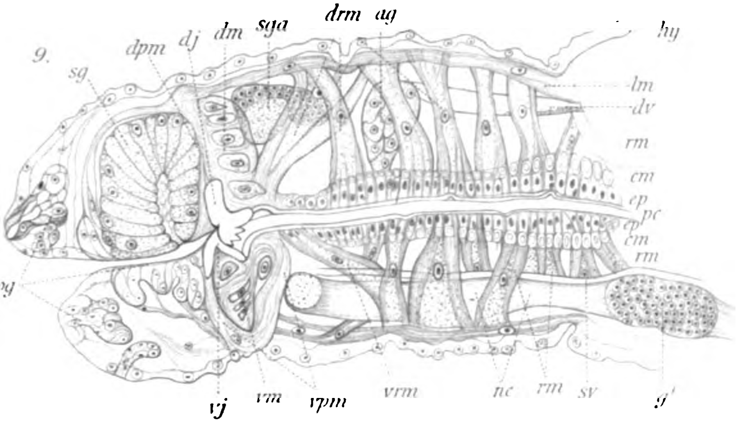

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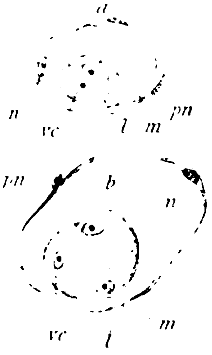

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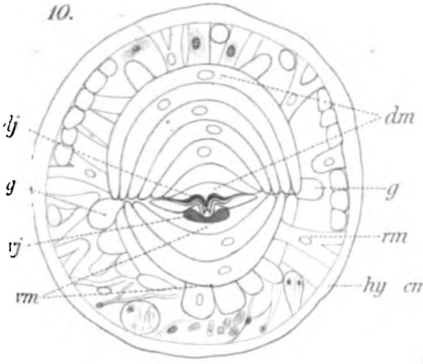

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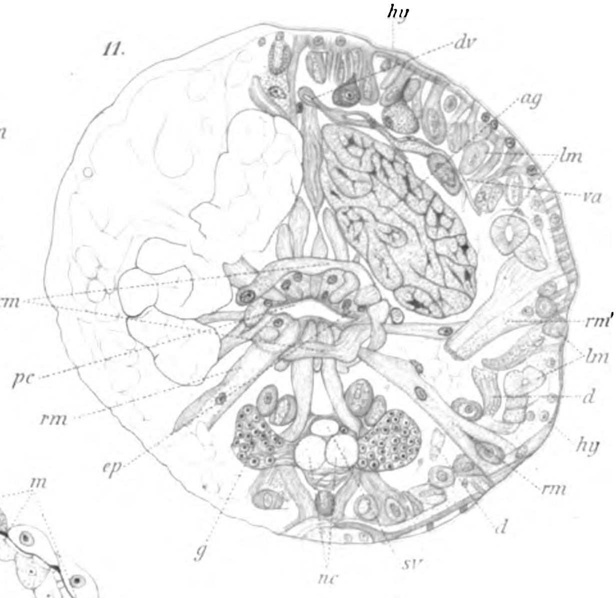

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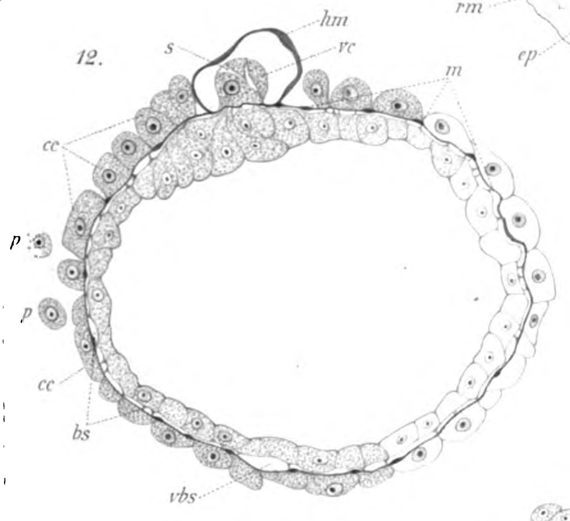

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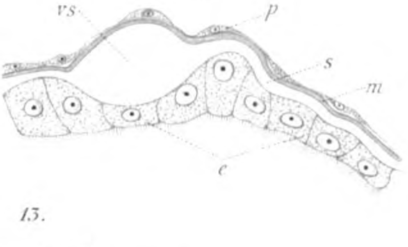

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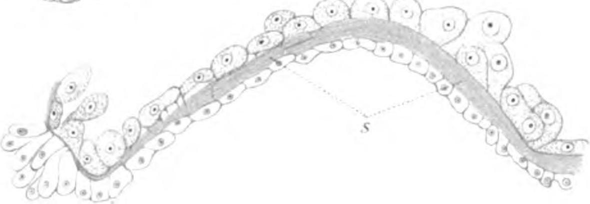


EXPLANATION OF PLATE XXX.

FIG. 16. Dorsal view of the ventral ganglia of the head, showing also the anterior termination of the supra-neural blood vessel. × 250. Reduced from a camera lucida drawing of a living specimen.

FIG. 17. Dorsal aspect of the supra-oesophageal ganglion, and termination of the dorsal blood-vessel of the same specimen. × 250. *sg*, principal, and sg^1, accessory lobes of the ganglion; *cc*, circum-oesophageal commissure; va^1 and va^2, the 1st and 2d vascular arches.

FIG. 18. Transverse section through the ventral nerve cord and ganglia of the 8th somite. Biondi-Ehrlich. × 500. *ln*, *ln*, lateral nerve trunks to body walls; *g*, ganglion cells; g^1, larger ganglion cells; *m*, muscular sheath of the nerve cord; *sv*, supra-neural blood vessel.

FIG. 19. The entire atrium of a mature worm, removed from the body and examined in a fresh condition under slight pressure. × 195. Camera lucida outlines, but the histology is purely diagrammatic, and is introduced only to differentiate the various regions. Viewed from the left side. vd^1 and vd^2, the anterior and posterior pairs of vasa deferentia; *sv*, glandular spermatic vesicle; sv^1, muscular spermatic vesicle; *lm*, longitudinal, and *cm*, circular muscle coats of the penis sheath and copulatory bursa; *ss*, sub-epithelial space; *pe*, penis; *g*, bursal glands; *e*, lining epithelium of bursa.

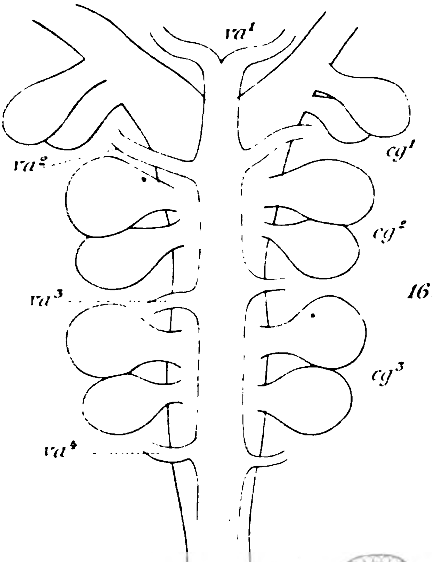
FIG. 20. The same seen from in front; the glandular sperm sac is displaced. Lettering as before.

FIG. 21. Transverse section of a vas deferens, showing the muscle cells and lining epithelium. Haem. × 840.

FIG. 22. Transverse section across the glandular sperm sac. Osmic acid and alum cochineal. × 500.

FIG. 23. Section through the point of union of the glandular and muscular sperm sacs, showing the abrupt change in the character of the epithelium, and the termination of the circular muscle coat. The section cuts the muscular sac transversely and near the side; and the glandular sac longitudinally and almost through its axis. *ge*, glandular epithelium; *e*, non-glandular epithelium; *m*, muscular coat; *p*, peritoneum.

FIG. 24. Vertical transverse section of the copulatory bursa, through the glands. The penis is abnormally retracted. Borax carmine. × 500. *g*, *g*, bursal glands; *e*, epithelium; *lm*, *lm*, longitudinal muscle coat; *tm*, circular muscles; *pe*, penis.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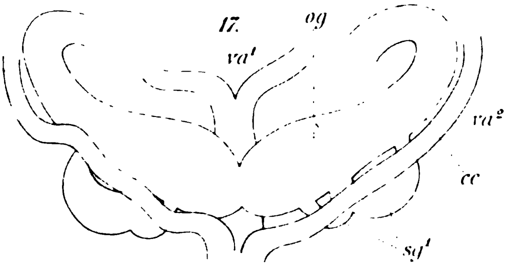
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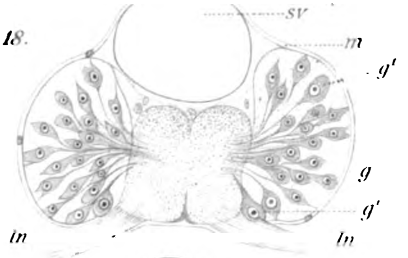
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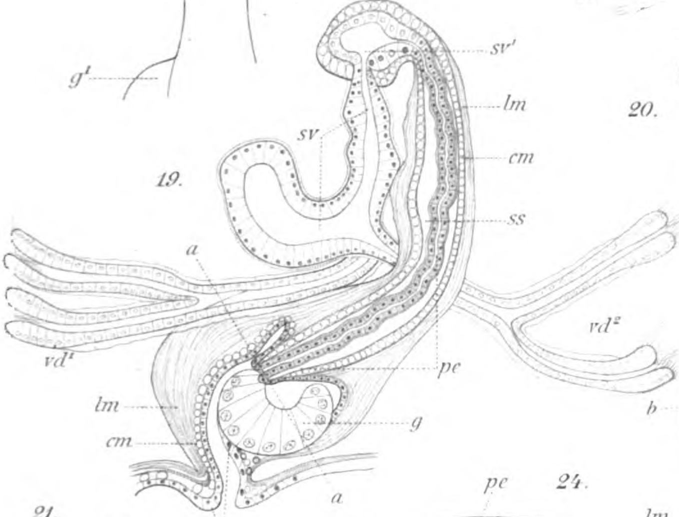
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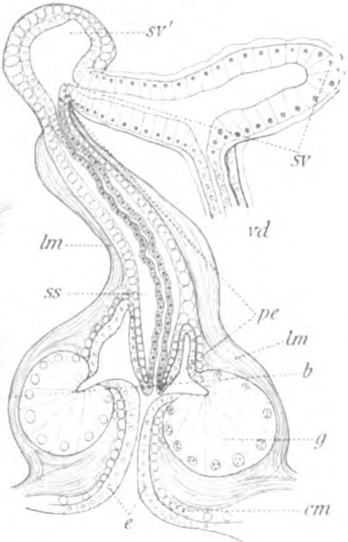
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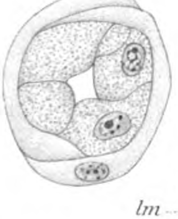
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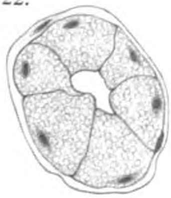
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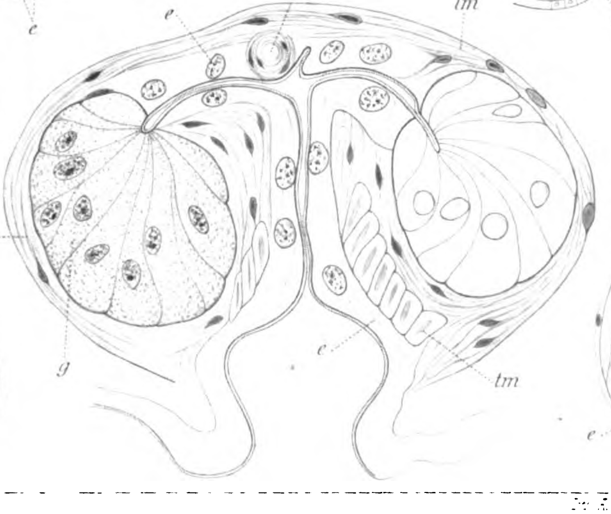
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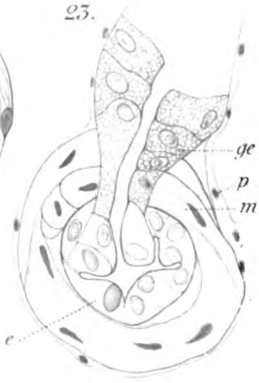
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EXPLANATION OF PLATE XXXI.

FIG. 25. Terminal portion of one of the anterior pair of vasa deferentia, from a preparation of the fresh material. × 500. *ml*, *ml*, limit of muscular layer, beyond which point are seen epithelial cells only; *mn*, nuclei of muscle fibres; *l*, lumen.

FIG. 26. Oblique section across the upper part of the copulatory bursa, approximately through the plane indicated by *a*, *a* in Fig. 19, and *b*, *b* in Fig. 20, from a preparation stained in Kleinenberg's haematoxylin. × 500. The right side of the figure reproduces the camera tracings unchanged, the left attempts to depict the appearance of the section. *lm*, longitudinal, and *tm*, circular muscle coats; *be*, epithelial lining of bursa, passing into the glands at two opposite points; *Po*, outer coat of the projecting end of the retracted penis (*Po* is made up of epithelium, circular, and longitudinal muscle fibres just above the plane of the section, but these were obscure in the specimen figured); *ses*, sub-epithelial space; *Pi*, circular muscles of the beginning invagination which forms the penis proper; *Pe*, penis epithelium; *Pl*, lumen.

FIG. 27. Small anterior portion of a longitudinal section through the ovary of a mature individual. Stained in Biondi-Ehrlich. × 500. *S* 6–7, muscular septa 6–7.

FIG. 28. Portion of a transverse section through the 7th somite of B. philadelphicus, showing the entire length of the left ovipore. Klein. haem. × 500. *o*, a mature ovum; *n*, its nucleus; *oe*, epithelium of ovipore passing into the peritoneum; *cm*, circular muscle fibre, between two of which the external opening is situated; *lm*, longitudinal muscles; *cg*, clitellar glands.

FIG. 29. Reconstruction (from camera tracings of a series of transverse sections) of a spermatheca, seen from behind. Klein. haem. × 195. *ep*, external opening lined by columnar epithelium; *gl*, posterior one of the pair of glands; *slm*, external layer of (longitudinal) muscle fibres, present on proximal portion only; *i*, inner, and *o*, outer limb; *lm*, longitudinal muscles of body walls; *n*, nerve cord.

FIG. 30. Transverse sections of the inner limb of a spermatheca near its blind end. The muscle fibres are here cut obliquely or transversely, owing to their spiral disposition. The appearance of the inner and outer zones in the epithelial cells is shown, and the several nucleoli and indications of an intra-nuclear network. Haem. × 840.

FIG. 31. Omitted.

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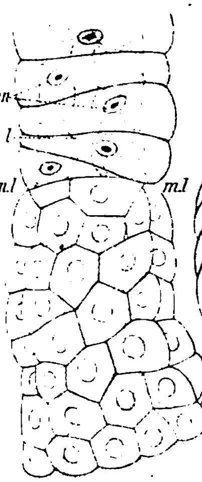

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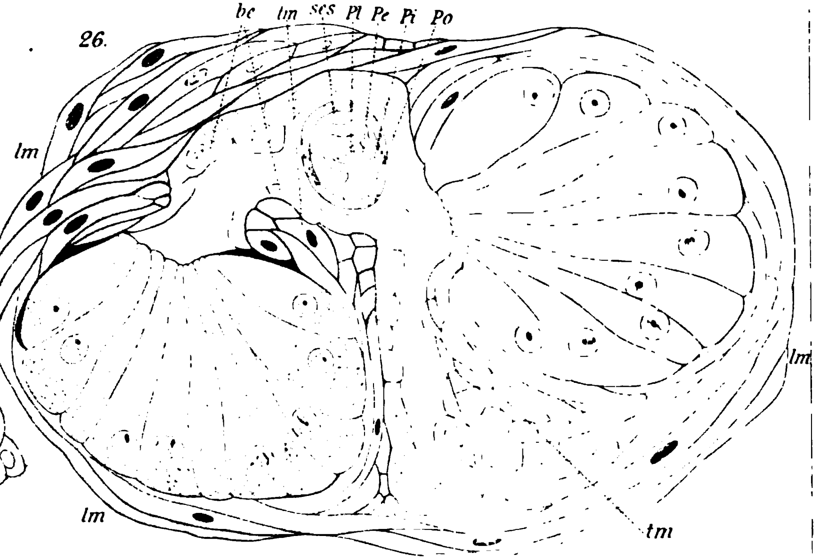

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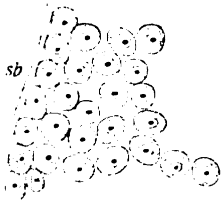

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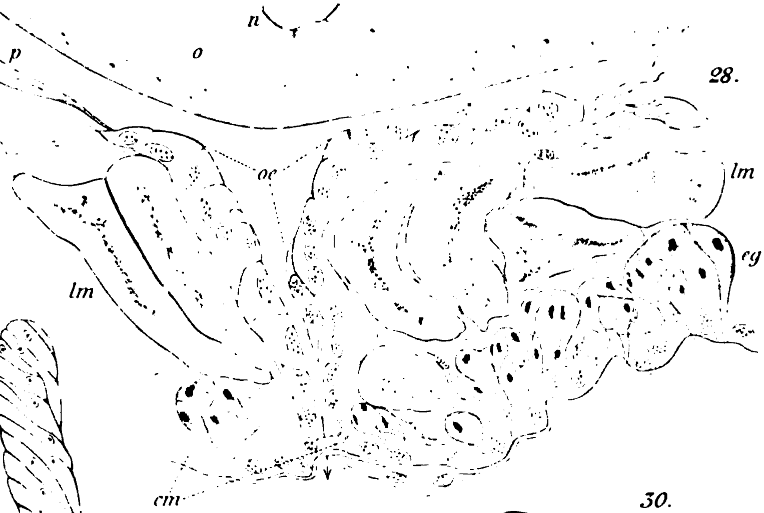

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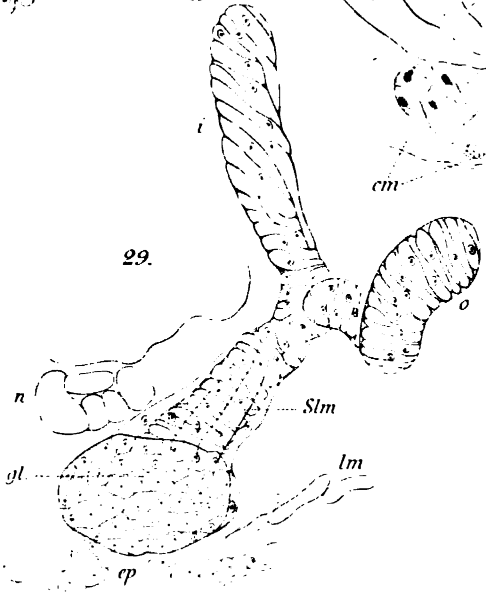

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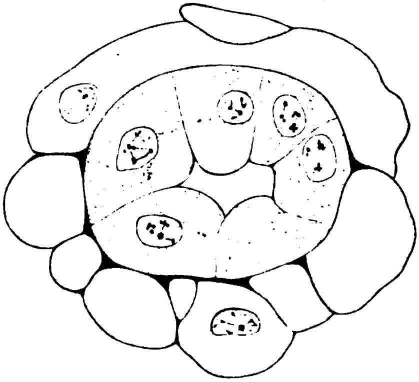

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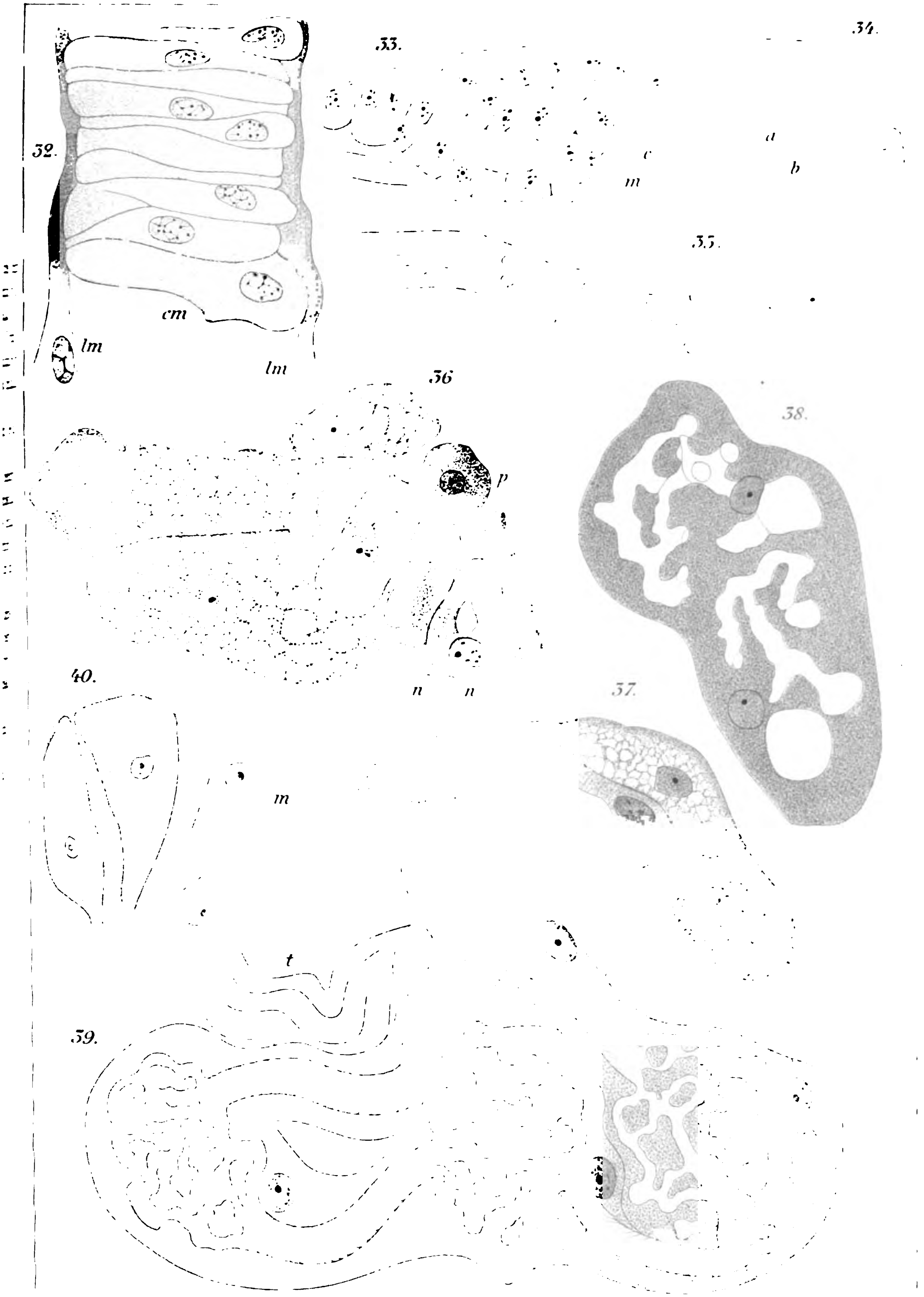
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EXPLANATION OF PLATE XXXII.

FIG. 32. Surface view of a portion of the circular muscle coat (the longitudinal muscle fibres are supposed to have been removed, with the exception of one on each side) of the undivided region of the spermatheca. Haem. × 840.

FIG. 33. Longitudinal section of the anterior nephridial vesicle. Borax carmine. × 500. *c*, the posterior chamber, which would be in communication with the anterior chamber in a section exactly through the median line; *m*, muscular coat, chiefly of circular fibres.

FIG. 34. Terminal portion, with external pore, of posterior nephridium; *en face* and in profile. Free-hand sketch from a living specimen. × about 275.

FIG. 35. Portion of terminal segment of tubule of the anterior right nephridium, at the point where it passes from the body cavity into the inter-muscular space. Sketch from a living worm. × about 350. The position of the nuclei midway between the lateral cæca of the lumen, the radial striation of a portion of the tubule, the considerable enlargement in size, and the peculiar looping of the lumen are shown.

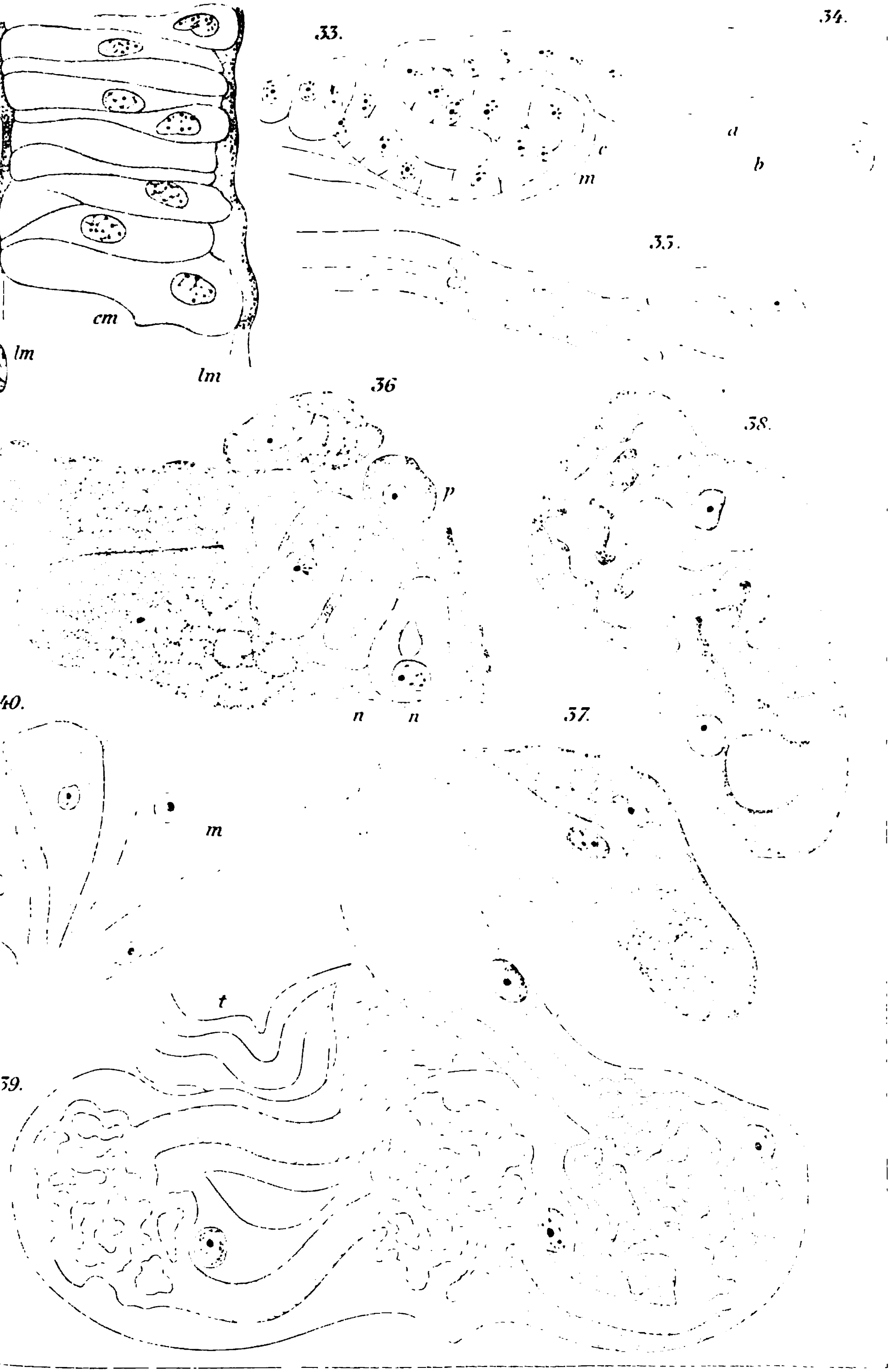
FIG. 36. Transverse section across a portion of the anterior loop of the anterior left nephridium, showing four tubules and their investment of enlarged peritoneal cells. The two tubules *n*, *n* have a more dense and radially striated protoplasm than the other pair, which show a reticulate arrangement. *p*, a peritoneal corpuscle. Klein. haem. × 500.

FIG. 37. Oblique section through a single tubule, from the same preparation. × 500.

FIG. 38. Transverse section of a nephridial nodule from the same preparation. × 500. Showing the intra-cellular plexus, and densely granular protoplasm. The two nuclei are located near the enlarged ends of two simple lumens, where they join the plexus. At these points the protoplasm shows radial markings.

FIG. 39. Optical section of three nephridial nodules, with the connecting sections of the simple tubule. Drawn with the aid of a camera lucida from a living specimen. The arrangement of the cilia is purely diagrammatic, and a few of the branches of the plexus were added to the camera tracing. The protoplasm and nuclei have, as nearly as could be copied, the appearance shown. × 500. From the anterior right nephridium. *t*, a short section of one of the loops of a simple tubule.

FIG. 40. Nephrostome of B. philadelphicus, drawn from a half-grown living specimen under pressure. × 840. *m*, muscle fibres, to which the nephrostome was attached.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UNITED STATES NATIONAL MUSEUM.

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THE LEECHES OF THE U. S. NATIONAL MUSEUM.

BY

J. PERCY MOORE,

Instructor in Zoology, University of Pennsylvania.

From the Proceedings of the United States National Museum, Vol. XXI, pages 543-563
(with Plate XL).

[No. 1160.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

THE LEECHES OF THE U. S. NATIONAL MUSEUM.

By J. PERCY MOORE,
Instructor in Zoology, University of Pennsylvania.

hrough the courtesy of the curators the collection of leeches con-
ied in the U. S. National Museum has been placed in my hands for
ly and determination. Though small, and much of it poorly pre-
ved, the collection has proved an interesting one. None of the forms
previously been identified; several have been found to be unde-
bed, several others have been mentioned in the literature but once
wice, and many are here recorded from new localities more or less
ote from those previously known. The material has been drawn
a various parts of the world, but it is to be regretted that our own
erican leeches are so poorly represented. Our fauna is a rich one,
is, perhaps, well known to but one person, who has as yet shared
little of his knowledge with the scientific public. We are still in
rly complete ignorance of the number and distribution of the species,
many interesting morphological questions remain to be elucidated.
one attempt has been made to systematize our knowledge—that of
f. A. E. Verrill twenty-five years ago—and that upon very inade-
te material from comparatively few localities. It is to be hoped
a greater interest will be taken in making well-preserved collec-
s, and that our National Museum will soon have gathered together
mplete series, not alone of leeches, but of annelids generally and
r worms as well.

his is perhaps not the most suitable occasion to enter upon a dis-
sion of any of the broader or more theoretical problems of morphol-
upon which the collection throws light. There is, however, one
ter of especial interest to the systematic student to which some
rence may profitably be made. I refer to the annulation of the
ite. My observations on this subject accord perfectly with the
rs expressed by Whitman (5 and 6) and later by Lang (4) and
nchard for the Glossiphonidæ, Hirudinidæ, and Herpobdellidæ, and
n pleased to be able to extend them to the Ichthyobdellidæ also,
ch has, I believe, not previously been done. Apathy (1), who has
le the most important recent contributions to the external morphol-
of the latter family, takes a precisely opposite view to that of

Whitman. He regards the multi-annulate somite as primitiv view here supported is that the primitive typical leech som sisted of three annuli. These primary annuli can readily be rec in all families and most species of leeches which I have ex When the primitive tri-annulate character of the somite is l may take place by (*a*) reduction, which has occurred as a r coalescence of the primary rings at the anterior and posterior nearly all leeches and in the genital regions of some, or (*b*) by tion, which has taken place in the somites of the middle body especially of the Gnathobdellidæ, Herpobdellidæ, and Ichthyob The increase in the number of annuli by which this elabo expressed externally seldom if ever occurs by the actual inter of new rings, but only by the growth and lesser or greater sub of the three primary rings. This subdivision seems to follow a law, which is that any number or all of the primary rings may secondarily bi-annulate, the secondary annuli similarly bi and the tertiary again divided for the fourth time, and of these subdivisions may be in various degrees partial or c and may affect one or more annuli of any order. The theoreti pleteness of the process is expressed in the following table, wh presents a system of nomenclature for the maximum possible nu annuli of each order, up to the fourth, of a complete somite, the structure of a typical somite of any genus to be express simple formula.

Table of annulations.

First order.		Second order.	Third order.	Fourth order.
Somite.	a 1	b 1	c 1	d 1
				d 2
			c 2	d 3
				d 4
		b 2	c 3	d 5
				d 6
			c 4	d 7
				d 8
	a 2	b 3	c 5	d 9
				d 10
			c 6	d 11
				d 12
		b 4	c 7	d 13
				d 14
			c 8	d 15
				d 16
	a 3	b 5	c 9	d 17
				d 18
			c 10	d 19
				d 20
		b 6	c 11	d 21
				d 22
			c 12	d 23
				d 24
Total.	3	6	12	24

I give a few illustrations of the application of the system. *clepsine* and many other Glossiphonidæ have a simple tri-annul ite $a1 + a2 + a3$. Many of the larger species of *Glossiphonia* slight subdivision of the second and third primary annuli, w comes strongly expressed in *Hæmentaria*, $a1 + a2\ (b3\ b4) +$

he Hirudinidæ generally this tendency is complete, and the five
li resulting are practically equivalent so far as size, etc., is con-
ed, $a1 + b3 + b4 + b5 + b6$ or $a1 + b3–6$. *Trachellobdella* has all
of the primary annuli subdivided, thus: $b1 + b2 + b3 + b4 + b5 +$
more simply $b1–6$. But in some of the species the divisions are
nplete, while in others those of the third order have set in, facts
may be expressed by the use of brackets, as shown above for
entaria. In *Dina* the third actual (fourth secondary) annulus is
ned and distinctly bi-annulate, expressible thus: $a1 + b3 + b4$ ($c7$
$b5 + b6$. The greatest complexity is found among the Ichthyob-
læ, of which *Cystobranchus* has the six secondary annuli, the third
metimes the fourth being subdivided. $b1 + b2 + c5 + c6 + b4 +$
6 or $b1–2 + c5–6 + b4–6$. *Piscicola* varies somewhat, but the most
ent arrangement is that in which the full number of annuli of the
order is developed, and two of these, namely, $c5$ and $c8$, are divided
nnuli of the fourth order, making in all fourteen annuli, expressed
e formula $c1–4 + d9 + d10 + c6 + c7 + d15 + d16 + c9–12$. In some
s the fourteen annuli become perfectly equivalent in size and the
of their formation obscure. No cases are known in which the
twenty-four of the possible annuli of the fourth order are devel-
or in which annuli of the fifth order are more than very slightly
ted.

tial or complete unions of adjacent annuli of neighboring somites
ently occur, and possibly entire somites may be absorbed, or
ations of new ones formed in the prostomial region. All of
conditions can be expressed in the formula, which could also
apted to indicate whether any given condition has arisen by sim-
tion or elaboration. The desirability of some more exact method
ining the annulation of the Ichthyobdellidæ must be obvious to
e who has noted the great confusion which reigns in this group
the number of annuli of each somite, and the scope of the genera.
ent authors have each usually attended to but one of the several
of division of the somite, and thus we have *Piscicola* (*Ichthyob-*
described with seven, twelve, or fourteen rings, each of which
sses a part of the truth.

combining the somite formula with the Roman numerals by
the individual somites are indicated, we can describe any annu-
esired with the greatest precision. As to the order of the elab·
n of the annuli in the Ichthyobdellidæ I have little light, except
he process begins in the middle primary annulus, and there also
eds the farthest. There are good physiological and mechanical
s for this; but I hope soon to have sufficient data for a fuller dis-
n of the external morphology of this family. This preliminary
nt is presented here in the hope that students of the Hirudinea
nd this scheme of sufficient value to test and perfect it. The
natic portion of the paper follows.

Family GLOSSIPHONIDÆ.

PROTOCLEPSINE, new genus.

This genus exhibits primitive external characters in the retention of the full number (3) of annuli in all of the anterior somites, and in the elevation of the eyes upon papillæ which stand in serial relation to the dorsal median segmental papillæ of the succeeding somites. The sexual pores occupy the usual positions in somites X and XI.

The type species has three pairs of eyes situated on somites I, II, and III; and the posterior somites XXII to XXVI are reduced.

1. PROTOCLEPSINE SEXOCULATA, new species.

(Plate XL, fig. 1.)

Unfortunately there is but a single much contracted specimen of thi interesting species. The prostomium is curled ventralward and th specimen is probably immature, so that the following measurement have a relative value only:

	mm.
Length	5.
Greatest width (XIXth somite)	2.
Depth at somite XIX	1.
Width at genital region	2.2-2.
Depth at genital region	About 1
Diameter of acetabulum	1.

In its contracted condition the body is truncated at both ends, th prostomium being curled under at the anterior end (corrected in th drawing, fig. 1), and the acetabulum drawn closely up at the posteri end. Consequently the body appears almost quadrate, with its greate width far back. It is strongly convex above and slightly concav below. The acetabulum is large and circular, with thickened ma gins. The anterior sucker is wide, with thickened crenulated margin formed posteriorly by annulus 5; its interior and the mouth openin are hidden by the infolded prostomium. A deep median and three pai of small lateral sulci divide the free margin of the prostomium int eight lobes, of which the four middle ones bear as many small papill Dorsally it consists of a larger anterior and a smaller posterior annulu

The somites I to XXI, inclusive, are complete, each consisting three annuli; XXII and XXIII are biannulate; XXIV and XX biannulate at the margins and undivided mesially; and XXVI consist of a single annulus. On each side of the middle line are three series dorsal and four series of ventral papillæ, situated on the first annul of each somite on which alone papillæ are evident. Of the dorsal seri the innermost are widely separated, leaving a broad median area; th outermost are supra-marginal, and the remaining series halfwa between these. All of the papillæ are smooth and rather inconspic ous. On the first, fourth and seventh rings behind the prostomiu papillæ of the innermost dorsal series are transformed into deeply nented eyes, but still retain their character as papillæ, being quite evated as the succeeding members of the series, with which they inue in perfect serial relation of position. Were any further evi- e required to demonstrate Whitman's view of the homology of the and segmental papillæ of leeches, this species would supply it. uli one and four lack the marginal but retain the intermediate llæ. The former begin on annulus seven and continue to somite V. The intermediate series ceases at somite XXIII, while the rmost continues to the post-anal annulus.

e ventral papillæ begin on annulus seven, which is united with They are a marginal, a mesial ventral, and two intermediate on side. The most mesial pair are widely separated and about oppo- o the mesial dorsal series. All are small, and in this specimen be detected with certainty on only a portion of the somites.

e individual described is probably immature, as the genital pores, ugh not difficult to detect, are very small, and their lips not en or glandular. The male pore is situated between annuli twenty- and thirty and the female between thirty-one and thirty-two. The is probably much changed in preservation, being a nearly uniform ze-brown. The eyes are black. Nothing is known of the internal omy.

pe.—No. 4320, U.S.N.M. Bering Island, Commander Islands, Sibe- Leonhard Stejneger, August 5, 1882, No. 1405. One specimen.

GLOSSIPHONIA Johnson.

2. GLOSSIPHONIA MOLLISSIMA.

(Plate XL, fig. 2.)

epsine mollissima GRUBE.

is species was described by Grube (3) from specimens collected at Baikal, Siberia. The following notes will serve to supplement e's description. The first pair of eyes are very small, deeply set, ometimes united to the second pair. They appear to be undergo- legeneration and absorption. The annulation of the first four es is shown in the following table:

Annulation of somites of Glossiphonia mollissima.

Somite.	Annuli.	Organ.
	Prostomium.	
I	1 } partly united.	First pair of eyes.
II	2	Second pair of eyes.
III	3 } united. 4 5 } united.	Third pair of eyes.
IV	6 7 8	

The prostomium consists of a single partial ring. The united third and fourth rings form the posterior margin of the anterior sucker. Somites III to XXII are complete, XXIII consists of annuli sixty-three and sixty-four, XXIV of sixty-five, which is double at the margins, XXV of sixty-six and XXVI of sixty-seven, behind which is the anus. The male pore is placed at X$a\frac{2}{3}$, or between the annuli twenty-five and twenty-six; the female at XI$a\frac{1}{2}$, or between twenty-seven and twenty-eight.

Character is given to the papillation by the great development of the dorsal median series, the papillæ of which are very large, and in some specimens the only ones distinctly developed. They become conspicuous on annulus fifteen, and are found on the first annulus of every complete somite thereafter, and on the annuli sixty-three, sixty-five, sixty-six, and sixty-seven. In the best preserved material they may be traced as far forward as annulus six. The mates are separated at the middle line by about one-fourth of the width of the body. The dorsal inner-lateral papillæ are also well marked on most specimens, and are found on the eye-bearing annuli, as well as on all those bearing the dorsal median ones. The outer lateral papillæ have become reduced to almost total suppression and were unnoticed by Grube. Very minute members of this series may usually be found on the eye-bearing and several succeeding papilliferous annuli. Besides the serial papillæ, very minute variable ones are found on the dorsum of all of the annuli. There are 10 or 12 small papillæ on the ventral surface of the first ring of each somite.

On the accompanying label Dr. Stejneger gives the following description of the colors of this species during life:

> Olive green, margins more brownish, two series of large whitish knobs along the back, and several smaller and less conspicuous spots between these and the margins. Along the back a regular system of narrow brownish longitudinal stripes.

This species closely resembles the *Clepsine elegans* of Verrill, from which it may be distinguished by the much larger dorsal median papillæ.

No. 4259, U.S.N.M. Bering Island, Commander Islands, Leonhard Stejneger. 1882–83. Twenty-two specimens.

3. GLOSSIPHONIA PARASITICA.

Hirudo parasitica SAY.
Clepsine ornata VERRILL (in part).

I have not yet acquired sufficient material to satisfy myself of the status of Verrill's species of *Clepsine;* but it is certain that both *C. ornata* and *C. papillata* are composite and in part synonymous. The types should be again studied and compared. I think that the forms here included can safely be regarded as cospecific with those forming the basis of Verrill's original description of *Clepsine ornata*, and their identity with Say's species was established by the examination of the supposed types in the collection of the Philadelphia Academy of

Natural Sciences. The following examples are included in the U. S. National Museum collection.

No. 5025, U.S.N.M. Vicinity of Fort Huachuca, Arizona. Dr. T. E. Wilcox, U. S. A. Five specimens.

No. 4025, U.S.N.M. Currant River, Shannon County, Missouri. R. Ellsworth. One specimen.

No. 5026, U.S.N.M. Pine Ridge Agency, South Dakota. Dr. Leonhard Stejneger, 1894. One specimen.

No. 823, U.S.N.M. North Red River, British America. R. Kennicott. One specimen.

No. 4694, U.S.N.M. Wheatland, Indiana. On *Chelydra serpentaria*. Fourteen specimens.

No. 4602, U.S.N.M. Keel-Foot Lake, Obion County, Tennessee (from a small creek emptying into lake near Idlewild Hotel), May 30, 1882. E. Palmer. One specimen, very badly dried up and shrunken, but apparently a large example of this species.

No. 5027, U.S.N.M., 50 miles from Bluefields, Nicaragua. C. W. Richmond. On turtle. Five specimens.

4. GLOSSIPHONIA LINEATA.

Clepsine papillata VERRILL *var. lineata.*

In many respects this species resembles *G. triserialis* E. Blanchard, but differs from this and resembles *G. bridgei* O. F. Müller in the position of the genital pores, which are separated by but one annulus. The external male orifice is situated at $\frac{X}{XI}$, ($\frac{24}{25}$), the female at XI $a\frac{1}{2}$, ($\frac{25}{26}$), the latter being the usual position. The white patches which flank the black papillæ appear to be more conspicuously developed in the Mexican specimens, making this a very beautiful species.

No. 4101, U.S.N.M. D'eau douce de la Canada de Marfil, Mexico. Prof. A. Dugès, February 8, 1882. Nineteen adult and numerous young specimens.

5. GLOSSIPHONIA STAGNALIS.

Hirudo stagnalis LINNÆUS.
Clepsine modesta VERRILL.

This species is very common and widely distributed over the United States. No characters have been found which serve to distinguish it from the well-known European form.

No. 1038, U.S.N.M. Woods Hole, Massachusetts, September 16, 1883. William Nye, jr.; fresh-water ponds. Six specimens.

No. 808, U.S.N.M. Woods Hole, Massachusetts, September 24, 1883. William Nye, jr.; fresh-water pond. Many specimens.

PLACOBDELLA R. Blanchard.

6. PLACOBDELLA MEXICANA, new species.

(Plate XL, fig. 3.)

This species is close to *Placobdella plana* (Whitman) R. Blanchard, but the annulation differs in several respects. The body is broad and depressed, and rather ovoid in outline. The largest specimen measures 14.7 mm. in length and 6 mm. in breadth at the widest part. The acetabulum is small and weak, and about 2.5 mm. in diameter.

The prostomium is undivided. It is followed by a rather wide ring, which bears the single pair of eyes on its posterior part, and the first pair of dorso-inner-lateral papillæ on its anterior part. A plain narrow ring follows, then a broad double one bearing the second pair of dorso-inner-lateral papillæ on its anterior half. A narrow ring completes with this double one somite III. Somite IV is in one specimen similarly constituted of a broad double ring and a narrow one; in the others it is constructed like the following somites of three rings, the first of which bears papillæ. Somite XXII is the last complete one; XXIII has two annuli, XXIV a single annulus, double at the margin, and XXV and XXVI each a single papillate annulus. The male pore is situated between the twenty-fourth and twenty-fifth, the female pore between the twenty-sixth and twenty-seventh, and the anus between the sixty-sixth and sixty-seventh annuli.

The dorso-median and dorso-inner-lateral papillæ are large and conspicuous, but low, smooth, and rounded. The former begin on annulus eight (somite V) and continue with the latter to somite XXVI. The outer lateral are small; they begin on annulus eleven, the first of somite VI, and continue to annulus fifty-nine (somite XXII). The second annulus also of each somite of the middle region of the body bears six series of small papillæ which lie mesiad to the corresponding ones of the first annulus.

The color of the alcoholic specimens is a rich chocolate brown blotched with lighter and darker brown, a branched figure of the latter color corresponding very closely with the branches of the intestine, and the pale spots in general with the papillæ. A median white line appears at the anterior and posterior ends of the body. Beginning anteriorly in a triangular area which includes the eyes, it is more or less interrupted and broken at the first annulus of each somite to the seventh, where the band fades out. On the second annulus of each of these somites the pale area runs out laterad in transverse bars, which on V reach nearly to the margins of the body. At the posterior end a similar narrow pale area extends forward from the anus to somite XXI. Marginal white spots occur metamerically on each somite. The posterior sucker is marked with alternating rays of brown and white, the latter being confined mainly to the marginal half.

Types.—No. 5028, U.S.N.M. Mexico; P. G. Jouy; No. 384. Three specimens.

HÆMENTARIA De Filippi.

7. HÆMENTARIA OFFICINALIS De Filippi.

. 1478, U.S.N.M. Guanajuato, Mexico; Prof. A. Dugès. Two mens.

Family ICHTHYOBDELLIDÆ.

TRACHELOBDELLA Diesing.

8. TRACHELOBDELLA VIVIDUS.

(Plate XL, fig. 4.)

stobranchus viridus VERRILL.

s species bears a striking resemblance to a *Cystobranchus*, but the lation and the position of the sexual pores are characteristically recently attributed by Blanchard to *Trachelobdella*.

two regions of the body are sharply distinguished. The anterior, contains the first eleven somites, is somewhat sunken into and aced by the first somite of the posterior region. Somites IX, X, I are narrowed to form the clitellum, in front of which the body htly expanded laterally. The anterior region includes twenty ct primary annuli posterior to the expanded "head," which latter, the first five annuli, constitute five somites. Somite VI is com- of three primary annuli, each of which is clearly biannulate. e VII is as large as the eight preceding annuli. Each of the pri- annuli is divided into two and these again halved dorsally, so that e annuli of the third order may be counted on the dorsal side. iddle primary annulus (*a* 2) of this somite is large, and its two dary annuli (*b* 3 and 4) have almost the value of the adjacent ry annuli. Somite VIII is similarly annulated, but shorter. The es IX, X, and XI are the clitellar somites and are each reduced to rimary annuli, which, with the exception of the last, are obscurely ulate. The male pore is located on the anterior margin of somite between this and the preceding annulus (16). On the ventral nnuli sixteen and seventeen are much enlarged and partly fused ifteen and eighteen, respectively. The female pore is between the eenth and nineteenth annuli, having the same relation to somite the male pore has to X. The twentieth annulus is obscure, being with and retracted within somite XI.

posterior body region is broad and depressed, the transverse and al diameters being about as two to one. The constriction shown figure in the posterior third of the body is probably the result of cident of preservation. The somites of this region are charac- d by the six secondary annuli, those of the second primary us (*a* 2) being largest and on the dorsal side again divided into rtiary annuli, thus: *b* 1–2+*c* 5–6–7–8+*b* 5–6. This latter char- is lost in the posterior somites. Somite XXII is the last complete one, behind which there are four additional obscurely biannulate preanal annuli.

There are eleven pairs of well-developed lateral vesicles, which diminish in size each way from the sixth. Behind the eleventh pair are two pairs of rudimentary vesicles, indicated by opaque whitish lateral thickenings of the rings. The well-developed vesicles occupy the sides of *b* 1 and *b* 2 of their somites, except the first, which extends onto the last ring of somite XI. There are indications of annulation of the anterior sucker, but too obscure in this specimen to be described.

No. 242, U.S.N.M. Woods Hole, Massachusetts; V. N. Edwards. One specimen.

9. TRACHELOBDELLA MACULATA, new species.

(Plate XL, fig. 6.)

The two body regions are well marked, the anterior slender and terete, the posterior broad, flattened, and raquet-shaped. The posterior sucker is small, little if at all directed ventralward, and is contracted to a slit-like opening.

There are thirteen pairs of respiratory vesicles, with a posterior rudimentary fourteenth. The anterior ones are indistinct and the largest (the ninth and tenth pairs) at the widest part of the body. This region is concave below and convex above from side to side. The anterior region is somewhat retracted within the posterior. The head (in the contracted specimen) is scarcely expanded, and its margin only slightly oblique. Its free margin tends to fold into four lobes, dorsal, ventral and two lateral.

As in most other species of the genus, the annulation of the anterior region is irregular and difficult of interpretation. In this specimen the difficulty is increased owing to the integument being gathered up at several spots, as it were, into loose tufts, which disturb the arrangement of the annuli. After a careful study I have fixed on the interpretation shown in the figure; but this needs to be confirmed by a study of more and better material. The clitellar region is sufficiently distinct. Six annulations are observable on the dorsal side of the head. Then follow two narrow rings in the constriction behind the head. Behind these follow, apparently, four complete somites (V to VIII) of three rings each, of which the first corresponds closely to the transverse bands of orange, the second and third to the ashy spots described below. The primary rings of somite VIII, as here provisionally identified, are subdivided into six secondary rings. The clitellum consists of the two primary partly orange-colored rings of somite IX, the two primary (divided into four secondary) uncolored rings of somite X, and the similarly constituted somite XI, of which the last ring is united with the first of somite XII. The male pore is between the two secondary rings of annulus seventeen (the first of somite X), and the female pore between the two secondary rings of annulus nineteen (the first of somite XI). They are consequently separated by four small secondary annuli.

The somites of the posterior region are hexamerous, but the three primary annuli are easily recognized; and the first and second of each somite, except XII, are undivided at the margins, where they are occupied by the paired respiratory vesicles. The vesicles, as in the species to be described next, extend over the first and second primary rings of each somite, though in many cases the second is only partly occupied. Anteriorly the vesicles are collapsed and, except for their color, indistinct, but posteriorly they become much more prominent. Traces of a rudimentary fourteenth pair are found just anterior to the anus.

The color pattern of this species is interesting, and has probably been derived from the breaking up and partial shifting of an annular pattern, which still persists to some extent in the anterior region. The general color above is a rich bright orange anteriorly, becoming faded to a pale yellow posteriorly, where it extends over much of the ventral surface also. The ventral surface of the anterior region, the greater part of the clitellum, and the head are of a pale ashy color, which spots the dorsal surface also. These ashy spots show a distinct tendency to become arranged in three longitudinal rows on the posterior region. They are mostly large and of irregular shapes, and very nearly correspond to the somites, but those of the middle series have shifted more or less toward the posterior end and sometimes become confluent with neighboring blotches. All are edged by a very narrow border of reddish brown. A few similar irregular blotches are seen on the ventral surface. A small orange patch surrounds the male pore, and there is a similar one on each side of the clitellum. On each side of the dorsal surface of the head is a large bright orange spot, leaving a median ashy area. In the figure the orange-colored parts are stippled, the ashy plain. The hexamerous structure of the posterior somites is represented only in XIX and XX, but the others are similar.

The single specimen measures:

	mm.
Length	13.5
Greatest breadth	4.2
Length of anterior region	3
Breadth at male pore	.9
Breadth of anterior sucker	1
Diameter of posterior sucker	1.5
Depth of posterior region of body	1

Type.—No. 1314, U.S.N.M. Steamer *Albatross*. Locality unknown.

10. TRACHELOBDELLA RUGOSA, new species.

(Plate XL, fig. 5.)

The adult specimens of this species have the broad depressed form shown in the figure; a young individual is terete, with the vesicles appended to the sides of the body, and connected by a broad lateral cutaneous fold lodging the marginal sinus, by the metameric enlarge-

Family HIRUDINIDÆ.

HAEMOPIS SAVIGNY.

24. HAEMOPIS MARMORATIS.

Hirudo marmorata SAY.
Not *Nephelis marmorata* VERRILL.
Aulastomum lacustre LEIDY.
Semiscolex grandis VERRILL.

This determination was made by the examination of what are probably Say's types, recently discovered in the collection of the Philadelphia Academy. Say's species differs from *H. sanguisuga* Linnæus chiefly in the constitution of somite VI, which in the latter species has, according to Whitman's figure (7), the three annuli of equal size and without indication of subdivision. *H. marmoratis*, on the other hand, has the second and third annuli (twelve and thirteen of the entire series) much wider than the first, and each completely divided into two by a distinct sulcus. The genital pores vary slightly in position, as indicated by the conflicting descriptions of Leidy and Verrill. The male pore is usually situated at the anterior border of annulus thirty-one and the female in thirty-six.

No. 5033, U.S.N.M. Yellowstone Park; C. Hart Merriam; Hayden's expedition, 1872. Eleven specimens.

No. 670, U.S.N.M. Havre de Grace; Milner, 1877. Three specimens. This is var. *trigris* Verrill.

No. 5034, U.S.N.M. Marsh, Leavenworth County, Kansas; Orsen Pattee. One specimen.

No. 4498, U.S.N.M. Bristol Bay, Alaska; C. L. McRay, September 27, 1883. One specimen.

25. HAEMOPIS LATERALIS.

Hirudo lateralis SAY.
Semiscolex terrestris FORBES.

The type of Say's species was recently discovered in the collection of the Philadelphia Academy.

The sixth somite of *H. lateralis* consists of five annuli; the sexual pores are consequently two annuli further back than in *H. marmoratis*. Say's specimens were all aquatic, Forbes's all terrestrial.

No. 4102, U.S.N.M. Olney, Illinois; July, 1885; J. and C. Walker. One specimen.

No. 625, U.S.N.M. Keelfoot Lake (small creek), near Idlewild Hotel, Obion County, Tennessee; Ed. Palmer; 1882. One specimen.

LIMNOBDELLA R. Blanchard.

26. LIMNOBDELLA MEXICANA R. Blanchard.

No. 202, U.S.N.M. Quanajuata, Mexico; Prof. A. Dugès. Three specimens.

MACROBDELLA Verrill.

Not *Macrobdella* PHILIPPI.

Verrill's use of *Macrobdella* seems to have priority, his paper having been published in February, 1872, while Philippi's was not published until October of that year.

27. MACROBDELLA DECORA (Say) Verrill.

Hirudo decora SAY.
Hirudo decora LEIDY.

No. 4599, U.S.N.M. Wytheville, Virginia; Col. M. McDonald, U. S. Fish Commission. Two specimens.

No. 4503, U.S.N.M. Fulton Lakes, Adirondacks; Fred. Mather, July 2, 1882. Thirteen specimens.

PHILOBDELLA Verrill.

Verrill established *Philobdella* as a subgenus of *Macrobdella*, though he inclined to raise it to the rank of a full genus, which is undoubtedly its proper systematic value. The most remarkable character of the genus is that the ducts of both male and female organs open externally within the limits of somite XI. The sexual adhesive organs are arranged around these pores.

28. PHILOBDELLA FLORIDANA Verrill.

The chief points in the annulation of this species are shown in the following table:

Annulation of Philobdella floridana.

Somites.	Annuli.	Organs.
	Prostomium.	
I	1	First pair of eyes.
II	2	Second pair of eyes.
III	3 4	Third pair of eyes.
IV	5 6 united ventrally. 7 united ventrally.	Fourth pair of eyes.
V	8 9 10	Fifth pair of eyes.
VI	11 12 13	First pair nephridiopores on posterior margin of 13.
VII	14 to 18	Second pair nephridiopores on posterior margin of 18.
VIII to X	19 to 33	Third to fifth pairs of nephridiopores on 23, 28, and 33.
XI	34 35 36 37 38	Male pore on 34. Female pore on 37. Sixth pair of nephridiopores on 38.
XII to XXII	39 to 93	Seventh to seventeenth and last pair of nephridiopores on 43 to 93.
XXIII	94 95 96	
XXIV	97 98	
XXV	99 100	
XXVI	101 102 partly united	Anus.
Not defined externally.		Posterior sucker.

Unfortunately no material is available for a study of the internal reproductive organs. The external arrangement is as follows: The median region of annuli thirty-four and thirty-five is pushed in to form a deep pit, which at its mouth is about 2 mm. across. It inclines cephalad and narrows toward the fundus. In one specimen it is at least 2.5 mm. deep. In the front wall, which corresponds to the inturned part of annulus thirty-four, is an orifice which appears to be the male pore. This is located more than a millimeter from the mouth of the pit and between a pair of glandular folds or papillæ, which, like those described below, has each a pore at its summit. Five additional adhesive organs are related to the male pore. A pair is located on the posterior margin of thirty-three, close to the median line. The papillæ are low and wide, and the pores large, oblique, and crescentic. A second pair is placed at the sides of the pit, just within its mouth and close to the posterior wall. A fifth and unpaired organ is placed on the posterior wall of the pit at a higher (more dorsal) level than the pair.

Behind the male pit a large, conical, sugar-loaf-shaped papilla rises from annuli thirty-six, thirty-seven and thirty-eight. At its slightly pointed summit is the female pore, within the limits of the thirty-seventh annulus. The papillæ incline slightly toward the posterior end of the body. On each side of the female pore and rather toward the posterior face of the papilla is an adhesive organ which in copulation would meet one of the pair between which the male pore is situated. Three more, a pair at the base and a single median one higher up, are found on the anterior face of the papilla, and in copulation would attach to the three in the posterior region of the male pit. Another pair is located on annulus thirty-eight, just outside of the base of the papilla, and corresponds to the male pair on annulus thirty-three. In addition to these there is a conspicuous pair farther out on thirty-eight, and on the posterior portion of thirty-nine (or on thirty-nine and forty of one specimen) a bilobed papilla with two pores on one side, and a linear trilobed one with three pores on the other side of the middle line, which have no visible counterpart in the male system. This last group alone probably corresponds to the similar organ of *Macrobdella*, the others being unrepresented in that genus.

All of these organs consist essentially of more or less prominent papillæ containing glandular sacs which open by apical pores, and whose cavities frequently contain hardened masses of mucus.

No. 4103, U.S.N.M. New Orleans, Louisiana; Dr. R. W. Shufeldt (No. 593), 1883, one specimen.

No. 4104, U.S.N.M. New Orleans, Louisiana; April, 1883; Dr. R. W. Shufeldt (No. 1140), one specimen.

No. 791, U.S.N.M. New Orleans, Louisiana; April, 1883; Dr. R. W. Shufeldt (No. 1139), one specimen.

GEOBDELLA Whitman.

Not *Geobdella* BLAINVILLE.
Chthonobdella GRUBE (in part).

The earlier use of *Geobdella* by Blainville to designate a different group of leeches will of course prevent its general use by systematists in the connection proposed by Whitman.

28. GEOBDELLA LIMBATA (Grube Whitman.

No. 173, U.S.N.M. New Zealand; U. S. Exploring Expedition; one specimen.

No. 174, U.S.N.M. New Zealand; U. S. Exploring Expedition; one specimen.

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EXPLANATION OF PLATE.

Plate XL.

Fig. 1. *Protoclepsine sexoculata*. General morphology of dorsal surface. x 10. The segmentation and arrangement of the papillæ is shown for all the somites.

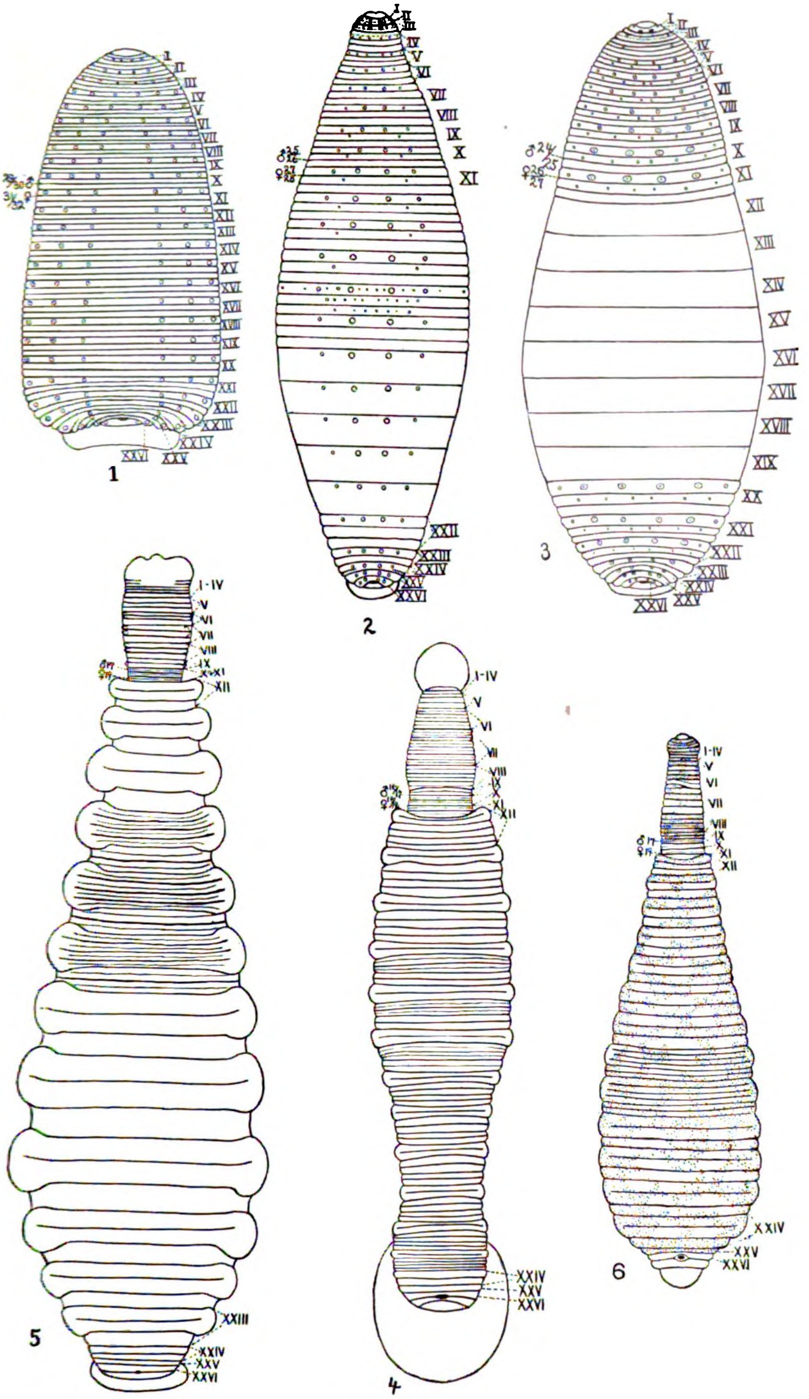
2. *Glossiphonia mollissima*. General morphology of dorsal surface. x 5. The annuli are omitted from several of the somites of the middle region. The characteristic and principal sensory papillæ are shown for all of the somites, but the smaller and variable ones fully on somite XVI only.

3. *Placobdella mexicana*. General morphology of dorsal surface. x 5. The characters of the anterior and posterior ends of the body only are shown.

4. *Trachelobdella rividus*. General morphology of dorsal surface. x 5. The tertiary annuli are shown for somites XV–XVII.

5. *Trachelobdella rugosa*. General morphology of dorsal surface. x 5. The integumental secondary and tertiary annuli of the middle region are shown only in somites XV–XVII.

6. *Trachelobdella maculata*. General morphology of the dorsal surface. x 5. The stippled areas are yellow. Secondary annuli shown in somites XIX and XX.



External Morphology of Leeches.

For explanation of plate see page 563.

J.P.
F.W. Crayfish

Mr. C. A. Kofoid
with compliments
of J Percy Moore

⑧

ON SOME LEECH-LIKE PARASITES OF AMERICAN CRAYFISHES.

BY J. PERCY MOORE.

In 1851 Dr. Leidy described in the Proceedings of this Academy the external characters of *Astacobdella philadelphica*, which he found occupying generally the exterior of *Cambarus bartonii.* This account was quoted in full in the Synopsis of American Freshwater Leeches published in 1874 by Verrill, who adds no observations of his own. Other than these the writer is acquainted with no published accounts of American Discodrilidæ (Vejdovsky). Attracted by the peculiar structure, the uncertain affinities, and most of all, by the remarkable variability of these parasites, a score of zoologists have been led to contribute to our knowledge of the European forms. The question of the specific distinctness or unity of the several forms which take up their abode on *Astacus fluviatilus* has led to considerable discussion, which has not yet reached a definite settlement. Vejdovsky believes the three or four forms which have been described as distinct species to be but varieties of one extremely variable species—a view to which a strong support is lent by the elaborate tables of variations prepared by Voigt. Whitman has found living on the crayfishes of Japan a similar multiplicity of forms, which have been regarded as constituting three distinct species, but which have not, the writer believes, been described.

It now appears that our American crayfishes likewise carry about with them a heterogeneous burden of leech-like parasites (or messmates?). Our common *Cambarus bartonii,* for example, is affected by at least four forms, which are easily distinguished, and which will be here described as specifically distinct. Other and different forms have been found by the writer on *C. affinis* and on *C.* ——— which inhabits the larger mountain streams of western North Carolina. These being the facts, the writer thought it well to present for publication the present short account, which is entirely preliminary to a more complete discussion of the structure and affinities of these Annulata, the first instalment of which will soon appear. It is hoped that this paper will serve to direct the attention of zoologists to this neglected group, and lead to the collection of the numerous forms which it seems reasonable to suppose must attach themselves to the bodies of our many species of crayfish. The monographic study of such a group as this would doubtless furnish us with data of great value in the consideration of our theories of variation. The writer would be especially indebted to anyone who will kindly furnish him with material collected in other localities or from other species of crayfish.

Regarding the specific distinctness of the forms here described it may be said that the writer has examined several hundred specimens ranging in size and age from individuals just emerged from the cocoon to those of the largest dimensions, and while each species exhibits a considerable range of variation (which will form the subject matter of a subsequent paper), no important transitional forms have been discovered, the diagnostic characters here given being maintained with as much constancy as is usual amongst closely allied animal species.

Even should the views of Vejdovsky and Voigt prove to be correct for the European species, which seems probable, this would in no way affect the status of the American forms; for other cases are not wanting where a group of animals which in one region is represented by a single variable species, in another has numerous specific representatives. This would then be only another fact in support of the view, now almost universally conceded, that species are but more widely separated varieties, which under the stress of changing conditions have continued to diverge from a common origin. Indeed, it is not certain that these species should be placed in the same genus even, for they are distinguished from one another by anatomical characters of such importance as would, in some groups of animals, rank of generic value. The several species are here referred to the single genus *Branchiobdella* chiefly because the writer is uncertain as to the legitimate limits of a genus in zoology, and because in this preliminary paper it is sufficient to recognize the existence of distinct forms without attempting to fix the exact conventional value of the gap which separates them—a labor which belongs more rightly to the systematist, whose work of sorting and arranging would be quite premature in a group of which only a very small portion of the probable number of existing species have been examined. Moreover it should be borne in mind that much confusion has resulted from the unnecessary multiplication of genera.

The four species of *Branchiobdella* here considered agree with one another, and differ from the European species (*B. varians* of Voigt =*B. astaci* Odier, + *parasita* Braun, + *pentodonta* Whitman, + *hexodonta* Gruber) in the possession of two pairs of vasa deferentia, in the fifth and sixth post-cephalic segments; while *B. variens*, as described by Dorner, whose account I have not seen corrected, has but one pair.

Our four species group themselves somewhat naturally in pairs. *B. philadelphica* and *B. illuminata* agree in the terete cross-section of the body, the posteriorly directed posterior sucker, the common external opening by means of a vesicle (which is pulsatile in *B. philadelphica*, at least) of the anterior pair of nephridia, and the unlike form of the dorsal and ventral jaws. *B. pulcherrima* and *B. instabilis* agree in having the body depressed and more or less laterally expanded posteriorly, in the ventral direction of the face of the sucker, the distinct external openings of the anterior two nephridia, and the similar dorsal and ventral jaws. The second group is much more closely allied to the European forms.

Branchiobdella illuminata, sp. nov.

Fig. 1*a*., Plate XII, external outline of the animal of its usual resting form, showing also the outline of the alimentary canal, the principal trunks of the vascular system, the series of clear glands of the right side, and the common nephridial vesicle opening to the exterior on the dorsum of the third post-cephalic segment, x23, drawn from a living pecimen. Fig. 1*b*, the two jaws in normal relative positions, x400. Fig. 1*e*, outline of a cocoon, x45.

This species has been named *illuminata* in allusion to the double series of clear glands which in mounted specimens viewed by transmitted light appear like rows of pale-lighted lamps.

Body very slender in complete extension, but robust in contraction, tapering from the seventh segment very gently toward the head, and suddenly to the posterior sucker; terete in transverse section in all regions. Bi-annulation of segments very conspicuous throughout the entire length. Posterior sucker small and weak, on the same axis as the body segment. Head small, slender, and elongated; the post-oral part distinctly bi-annulate. Lips long and weak, of nearly equal size; ridged within by longitudinal folds. Mouth opening with its longest diameter transverse. No circumoral or other hairs have been detected in the adults of this species; and in the young is single small bunch in the median region of each lip is all that is present.

The jaws are remarkable, and although large, are inconspicuous on account of their transparency and lack of color. On the dorsal one, which is much the larger, a high median ridge is developed, which bears three strong teeth, the points of which are directed posteriorly (down the throat). The ventral jaw is shaped like a U each limb of which is bent out of the common plane into a boomerang shape. The angle of the boomerang on each side is uppermost and bears a very strong curved tooth, the two bounding a deep groove which accommodates the dorsal dentigerous ridge.

The stomach is comparatively small, and behind it the evenly tubular intestine is thrown into loops, which become more obvious with the greater degree of contraction of the animal.

In connection with the vascular system is developed a remarkable shallow sinus which covers almost the entire surface of the alimentary canal. This presents dorsal and ventral longitudinal enlargements into which the principal vascular trunks are received. The extensive vascular surface with the contained bright red blood thus presented gives the animals a delicate pinkish hue which distinguishes living individuals at a glance from the other species herein described.

In each of the nine post-cephalic segments is a pair of peculiar translucent glandular bodies composed of large nucleated cells, and communicating with the exterior by slender ducts having ventrolateral openings.

The anterior two nephridia open into a gourd-shaped vesicle having an opening to the exterior in the mid-dorsal region of the major annulus of the third segment. The spermatheca is short, cylindrical and bifid ; the penis-sac short-pedicled and spherical, and the atrium clavate and curved. The spermatheca, penis, ovaries, posterior paired nephridia and anus open respectively on the fifth, sixth, seventh, eighth and ninth post-cephalic segments. Length of full grown individuals, 4 mm., maximum diameter (7th segment) ·9 mm., diameter of acetabulum ·35 mm. The figure represents an individual of maximum size.

The cocoon is regularly ellipsoidal in shape and bears an anchoring pedicle at each pole of the major axis. Length of cocoon, ·55 mm., diameter, ·40 mm., length of pedicles, ·33 mm.

This species is very common and has been found in the branchial chamber of nearly one-half of the larger individuals of *C. bartonii* that I have examined. It appears never to leave the branchial chamber during the life of the crayfish, except at the time of moult. The cocoons are found throughout the year attached to the branchial filaments, especially the inner ones. Philadelphia, Pa. and Watauga Co., North Carolina.

B. pulcherrima, sp. nov.

Fig. 2*a*, Plate XII, outline of the entire animal as seen from the side, showing the adhesive organs on the eighth and ninth segments, x23. Fig. 2*b*, the same specimen from the dorsal aspect, with an outl ine of the alimentary canal, x23. These drawings are from a medium sized preserved specimen. Fig. 2*c*, one of the jaws of the usual form, x200. Fig. 2*e*, a cocoon, x45.

The beautiful transparency of the anterior segments, which enables one to see with great distinctness the internal organs of that region suggested the name given to this species.

Form rather stout, the body depressed, especially in the posterior region. The segments increase regularly in width to the seventh, which is the broadest; and behind which they rapidly narrow to the acetabulum. Each post-cephalic segment consists of an anterior larger and a posterior smaller annulus. The ventral surfaces of the eighth and ninth segments are strongly flattened, and each bears on its extreme lateral margins a cup-shaped adhesive organ, into the central depression of which a conspicuous gland opens. These are directed ventralward and doubtless serve as accessory organs of attachment to aid the rather weak sucker. Those on the eighth segment are usually the larger, but a considerable range of variation is exhibited in this respect. The structures become proportionally larger and more conspicuous in older individuals.

The head is urn-shaped, slightly longer than broad in preserved specimens, and its greatest width less than or just equal to that of the first body segment. The breadth of the head varies greatly with the degree of contraction of the specimen, but in the living individual always appears narrow, and to form part of the generally even tapering outlines of the body, never abruptly expanded as in *B. instabilis*. The oral region is separated from the cephalic region by a deep constriction, which completely encircles the head. The mouth is enveloped by a pair (dorsal and ventral) of distinct thick muscular lips, of which the dorsal one is the larger and droops downward, partially enclosing the ventral lip. Each presents a slight median emargination, but is otherwise entire. The lips and head, as well as the sides of the principal annuli of the body, are provided with a fringe of delicate hairs. Mouth opening nearly circular, between the parted lips.

The jaws are small and inconspicuous, in adult specimens less than one-twelfth of the width of the head, and of a pale brown or amber color. The rounded base bears three teeth, of which the larger lateral ones are stout, curved, and divergent, while the smaller median one is straight and sharp-pointed. The variations in the jaws involve frequent unsymmetrical development of the teeth. The dorsal and ventral jaws are similar, and both are fixed opposite to the constriction behind the lips, the teeth being directed inward.

The straight alimentary canal is strongly sacculated in the second, third and fourth segments, behind which it is narrow, and direct in its course to the anus, which opens on a slight papilla on the dorsal side of the ninth segment.

The greater part of the body cavity of the fifth and sixth segments is filled with testicular cells in various stages of development; and the glandular thickening of the skin of these segments renders the walls conspicuously opaque. The two pairs of vasa deferentia open into the nearly spherical atrium in the sixth segment. A conspicuous and broadly pyriform spermatheca opens on the fifth segment. The ovaries and accessory structures occupy the seventh. The anterior nephridia alternate in position, but open to the exterior by paired orifices in segment three. The posterior paired nephridia occupy the space on each side of the intestine in segment eight.

This species is colorless and more or less translucent; the first four segments behind the head are remarkably clear and translucent, but behind this the body walls are rather opaque and the position of the internal organs obscured. The alimentary canal is throughout darkly colored, except within the head.

Blood very pale red.

Length of mature individuals	6 mm.
Maximum breadth	1·3 "
Width of jaws ·	·06 "
Diameter of acetabulum	·6 "

Cocoons of this species are almost spherical and are borne on short stout stalks. Usually they are attached to the broad surfaces of the body, *i. e.*, the sides of the carapace, inner faces of the anterior abdominal epimera, and the sternal face of the tail fin.

Length of cocoon without stalk . . . . . ·46 mm.

The adults are found attached almost anywhere on the exterior of the crayfish but more especially on the tergal surface.

Watauga Co. North Carolina, on *Cambarus bartonii.*

B. instabilia, sp. nov.

Fig. 3*a*, Plate XII, an unusually large individual seen from the ventral side, showing the outlines of body and alimentary canal. Drawn from a living individual in nearly full extension, x25.

Fig. 3*b*, and 3*c*, two views of the jaws, x200.

Fig. 3*e*, a cocoon, x45.

The constant movements of the lips, and the varying form of the head and segments succeeding it during the life of the animal make the name *instabilia*, the changeable, most appropriate.

Body in a state of contraction very short and stout, the posterior four segments forming a flattened disk-shaped expansion which is scarcely longer than broad; the first four body segments are much more narrow, but increase somewhat in breadth to the fourth, posterior to which the increase is very rapid to the seventh; the eighth is slightly narrower and develops lateral wing-like flaps, which, sloping ventralward, bound a decided ventral concavity in this region; posteriorly they embrace the sucker-bearing segments. The head and anterior segments are terete. Under normal conditions the large head is considerably broader than the following segments, which form a neck-like constriction, to which the head is attached by a very mobile fold, forming a distinct annulus. The emarginated lips are slightly crenulated, and form an almost continuous muscular thickening around the mouth. The post-oral constriction is well marked, but not so deep as in *B. pulcherrima.* Numerous short stiff hairs fringe the lips and head, and in young individuals are present on the body segments also.

The dark brown jaws are provided with four strong, curved, conical teeth, which diverge slightly; the outer pair are symmetrical, the left tooth of the middle pair is much larger than the right; this being the case in both jaws in nearly all of the many specimens examined.

The acetabulum resembles that of *B. pulcherrima* in being directed ventralward. Its diameter is greater than that of the first or second body segments. Bi-annulation is conspicuous on the anterior four post-cephalic segments only.

The alimentary canal is strongly sacculated in the fourth and fifth segments, in the sixth is pushed to the left side by the development of the atrium (this occurs in adults only), in the seventh is thrown into a complete double transverse loop which passes first to the right and then to the left, and finally passes directly to the anus in the ninth body segment. The spermatheca is very small and inconspicuous, while the penis-sac is well developed, and possesses a long vermiform appendage (atrium) which forms a loop dorsally over and around the intestine. Sexual and nephridial openings as in *B. pulcherrima.*

In contraction the body of this species is shaped like a short-handled raquet; in extention it has the outline of an Indian club from dorsal and ventral views.

Length of mature animal	5·5	mm.
Maximum breadth, ...	1·3	"
Diameter of acetabulum	·5	"
Transverse diameter of jaw	·048	"
Length of cocoon without pedicle	·35	"

The cocoons resemble those of the last described species, but are frequently provided with an apical fibrous tuft. They are invariably attached (to the extent of my experience) to the palmar surface of the propodite of the great chelæ. The animals themselves are largely restricted in their distribution to the same segments of the limb, and are usually to be found in numbers clustered at the base of the pincers to which position the form of the body peculiarly adapts them; for while the constricted anterior region, by reason of its tenuity, easily escapes crushing between the closing limbs of the chela, in which position it is frequently liable to be caught, the important organs of reproduction and digestion are massed together near the base of attachment, entirely out of reach of danger from this source. Frequently they wander to other parts of the same pair of limbs, or even to the two pairs of ambulatory limbs following.

Watauga Co., North Carolina, and by Mr. P. P. Calvert in Delaware Co., Penna.

B. philadelphica Leidy. *Astacobdella philadelphica* Leidy, Pro. Acad. Nat. Sci. Phila., 1851, p. 209, Verrill, Rep. U. S. Com. Fisheries for 1872-73, p. 688.

Fig. 4*a*, Plate XII, shows the external outlines of the body, and the alimentary canal of a moderately sized living adult, x23. Figs. 4*b* and *c* represents the dorsal, and 4*d* the ventral jaw, x100. Fig. 4*c*, cocoon, x45.

Dr. Leidy's description is here reproduced "Body whitish, translucent; sides nearly parallel, a little broader posteriorly, sixteen alternately broad and narrow segments exclusive of head and posterior end. Head campanulate, terminated by a circular or elliptical crenated lip, fringed with very minute stiff hairs, one two-thousandth of an inch long. Acetabulum circular, one-sixth or one-fourth of a line in diameter; mouth elliptical. Dental plates brown, nearly equal, forming an isosceles triangle, with the base longest and attached apex of superior plate ending in a sharp conical point; with several very minute denticulations on each side, apex of inferior plate bifurcated into two points, with two minute denticulations on each side. Stomach capacious, nearly filling the anterior eight alternately broad and narrow segments posterior to the head. Anus dorsal, one-fifth of a line from the acetabulum. Generative opening ventral, anterior to the anal aperture. Length, one to four lines; breadth, one-sixth to one-half of a line. Head, one-sixth to one-half of a line long. Ovum attached by a pedicle, with an operculum pointed at summit. From base of attachment to point of opercle, one-fifth of a line. Length of body of ovum, one-sixth of a line; breadth, one-eighth of a line.

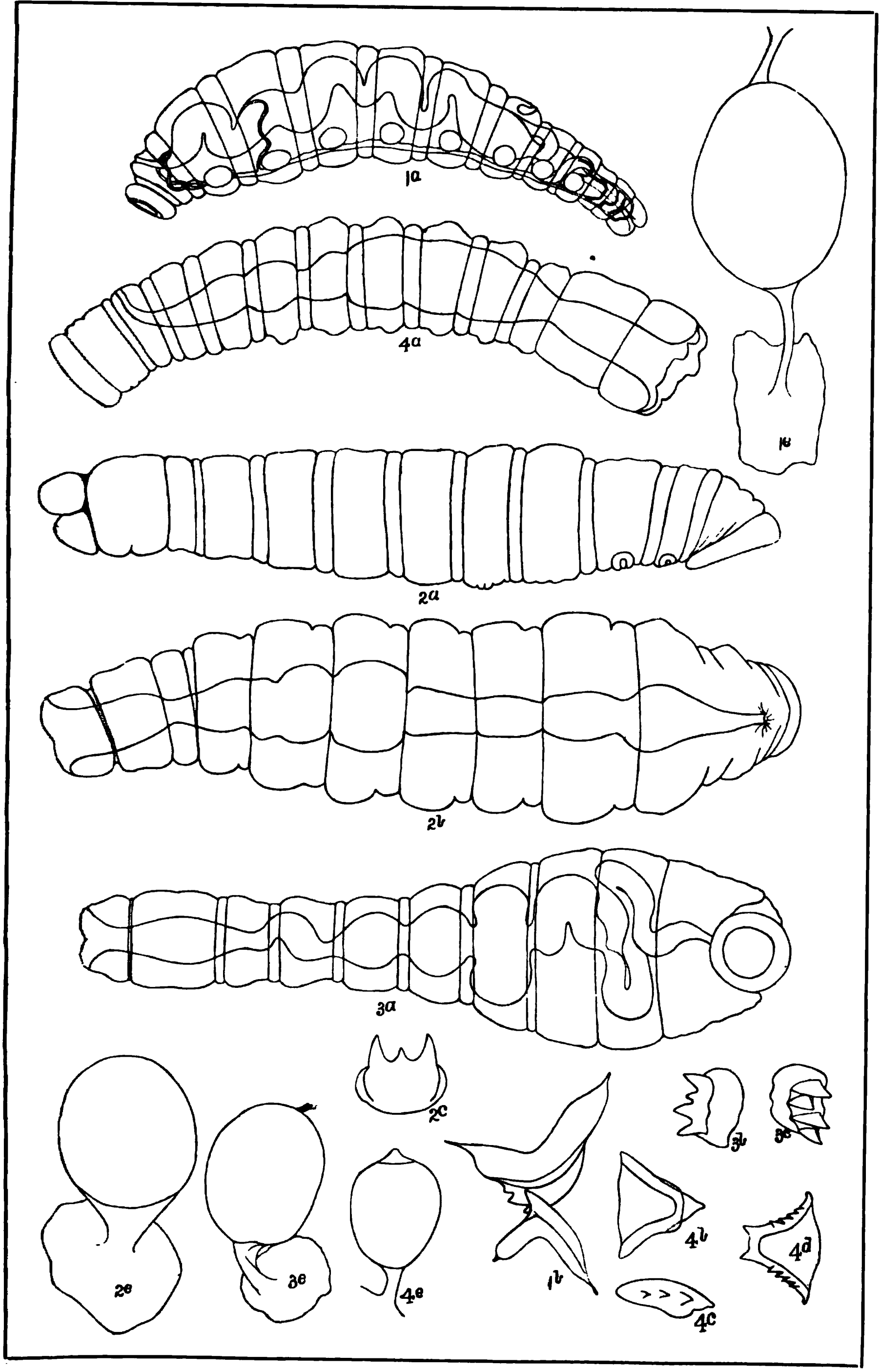
"Habitat.—Found frequently in numbers from one to several dozen upon any part of the exterior of the body of *Astacus bartonii* Fab., but more especially upon the inferior surface and the branchiæ."

The spermatheca is large, short-cylindrical, and curved; and the penis-sac is cylindrical and possesses prominent atrial appendage. The external openings of these and the ovaries are as usual. The anterior nephridia terminate in very large transverse tubes which open into a pulsatile vesicles ituated in the third segment. The other anatomica characters are in no way remarkable.

I have never found this species inhabiting the branchial chamber, but principally the sternal surface of the entire body, among the bases of the appendages. The cocoons are attached to the abdominal sternites, but more frequently to the setæ of the pleopods. They are to be found principally in summer, but are not entirely absent at any season.

Phila. Pa., and Watauga Co., North Carolina.

The author has, since writing the above, examined a preparation of *B. parasita* Braun, in which he was able to distinguish only a single unpaired vas deferens. Compare Vejdovsky, Systemu Monographie der Oligochæten.



MOORE: PARASITES OF CRAYFISHES.

re, Veranus A, Ravenel, M P and Sedgwick, W T

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Issued May 27, 1916.

United States Department of Agriculture,

OFFICE OF THE SECRETARY—CIRCULAR NO. 58.

REPORTS OF DRS. VERANUS A. MOORE, MAZŸCK P. RAVENEL, AND WILLIAM T. SEDGWICK UPON THE FEDERAL MEAT INSPECTION.

NOTE BY THE DEPARTMENT.

In July, 1913, the Secretary of Agriculture, wishing to obtain the opinions and recommendations of experts outside of the department with regard to the meat-inspection service as carried on by the Bureau of Animal Industry, requested the following-named gentlemen to investigate the work at the places respectively indicated and to report to him:

J. W. Connaway, D. V. S., professor of veterinary science in the College of Agriculture, University of Missouri, Columbia, Mo., to investigate the meat inspection at National Stock Yards (East St. Louis), Ill., St. Louis and St. Joseph, Mo., and Kansas City, Kans.

Veranus A. Moore, M. D., V. M. D., dean of the New York State Veterinary College and professor of comparative pathology and meat inspection, Cornell University, Ithaca, N. Y., to investigate the meat inspection at New York and Buffalo, N. Y., and Philadelphia and Pittsburgh, Pa.

Mazÿck P. Ravenel, M. D., professor of hygiene in the University of Wisconsin and director of the Wisconsin State Laboratory of Hygiene, Madison, Wis., to investigate the work at Milwaukee, Wis., Chicago, Ill., Indianapolis, Ind., and St. Paul, Minn.

William T. Sedgwick, Ph. D., Hon. Sc. D., professor of biology and public health and director of the sanitary research laboratory and sewage experiment station of the Massachusetts Institute of Technology, Boston, Mass.; also a member of the advisory board of the hygienic laboratory of the United States Public Health Service; to investigate the meat inspection at Boston and Worcester, Mass., and New Haven, Conn.

The letters of appointment by the Secretary contained the following statement:

> With a view to safeguarding public health and maintaining the highest degree of efficiency in the meat-inspection service of this department, it is my desire that you report directly to me fully and frankly the conditions as you find them at the various packing establishments, together with such recommendations looking to the improvement of the service as in your judgment may seem best.

Personal affairs made it impossible for Dr. Connaway to serve, but the others investigated and studied the inspection service in the course of the next few months. It was the Secretary's desire that the investigators, if possible, exchange views and collaborate in a joint report. As Dr. Sedgwick was preparing to go abroad, he made a separate report on March 1, 1914. After the lapse of some time, during which it was hoped that Dr. Connaway might be able to take the part desired of him, and after further delay due to other circumstances, Drs. Ravenel and Moore submitted their joint report under date of October 9, 1915. These reports follow:

REPORT OF DR. SEDGWICK.

I beg leave to report that acting under your letter of appointment and instructions, dated July 7, 1913, I have visited and carefully inspected the sanitary conditions affecting or likely to affect the public health in the principal packing houses engaged in interstate commerce at New Haven, Conn., and Worcester, Mass. In each city there is one principal slaughterhouse besides various establishments devoted to the smoking, packing, cutting, packing, and distributing of meat products. There is also under inspection in each city one detached rendering plant dealing chiefly with market waste and comprising under one roof carefully separated rooms and apparatus for rendering such waste into edible or into inedible materials.

I first made a general survey of the sanitary conditions surrounding the killing, dressing, cutting, and packing processes. I inquired into the water supply, the drainage, the methods of heating, lighting, ventilation, the physical conditions of floors, walls, cellars, etc. I considered matters of general cleanliness, of the health of the employees, of toilet facilities, and of the cutting, preparing, handling, packing, and shipping of the various products. These and similar inquiries I understand to be embraced under that portion of my instructions referred to as "conditions."

In the second place, and finally, I have observed closely the actual conduct of the work of inspection and in particular the character and efficiency of the personnel engaged in the inspection.

SANITARY CONDITIONS.

In New Haven and in Worcester the buildings are old but have been extensively reconstructed and are to-day reasonably well fitted and equipped for the work done in them. Hogs only are slaughtered in New Haven, and these arrive by train and, while awaiting slaughter, are housed under good sanitary conditions. The killing, the scalding, the scraping, and the eviscerating are all likewise done under reasonably good sanitary conditions. The floors, walls, benches, cooling rooms, cutting rooms, pickling and other storage rooms, the rooms in which sausages and luncheon loaf are made, the packing, salting, and shipping rooms are all in excellent sanitary and physical condition. Satisfactory measures appear also to be taken against flies and rats.

Reasonable care appears also to be used in the selection of healthy employees, and the toilet arrangements of the establishment are clean, well equipped, and sanitary. Their location, on the other hand, in New Haven is objectionable, as all are on the top floor and hence inconvenient for employees working on the lower floors. It is always of the very first sanitary importance to make resort to water-closets and hand-washing basins so easy and so convenient as to encourage habits of personal cleanliness. To this end hot as well as cold water should be freely accessible for hand washing. In New Haven the toilets are, as stated, on the upper floor, a somewhat inconvenient and, to this extent, objectionable location; but they are otherwise satisfactory and well appointed. At Worcester they are found on the various floors and are usually well ventilated and well appointed.

THE INSPECTION SYSTEM AND STAFF.

The system of meat inspection employed at the packing houses which I have visited has naturally the advantages and disadvantages of any inspection system, and I do not feel qualified either by training or experience to express an opinion on many of the technical points involved in its conduct or operation. I am, however, familiar with various other systems of sanitary inspection and I therefore feel competent to report upon certain features of this one.

I have observed closely the personnel of the inspecting staff and the personnel of the management or operating staff, and the reciprocal relation of these, together with the attitude of both to the work in hand. For, no matter what the physical environment, almost everything in work of this kind depends in the last analysis on the ability, faithfulness, and right attitude of those in charge. With an efficient and faithful personnel even a poor environment may be made to yield a good product, while with an incompetent or unfaithful staff even a model plant may turn out a poor product. Throughout the present investigation I was constantly impressed with the absolute and fundamental dependence of the results upon the interest, ability, and devotion of the personnel.

I was struck at the outset with the fact that the inspectors in charge are comparatively young men, energetic, and capable of hard work. The work which they have to do requires keen and unremitting attention often for hours at a time. Every carcass passes, almost literally, through their hands. Much of the work is done under wet, steaming, bloody, and otherwise disagreeable conditions. Much of it must be done rather quickly, and hence requires the closest concentration. The handling for hours of hot viscera sometimes makes the hands sore. Sharp knives must be constantly used and cuts are not rare, while a routine which is almost endless tends to deaden interest and dull the quickness of perception. For these and other obvious reasons such as the omnipresent possibility of temptations to indolence, carelessness, and even bribery it is plain that almost everything depends on the composition and character of the personnel. And here I am happy to be able to report that I have been impressed throughout by the obvious ability and apparent faithfulness of the inspecting staff. In the inspectors in charge at the stations visited I believe that the Bureau of Animal Industry possesses men of character, ability, and faithfulness. Of those under them I can say but little in detail, but as far as my observation went all are supported by competent and faithful assistants.

It is of course imperative if not indispensable that the inspecting staff should be on good terms with those managing and operating the plant. And here by separate and special inquiry, I satisfied myself that the relations were such as ought to prevail. A steady yet reasonable pressure seems to be exerted upon the owners and managers to make improvements, and I repeatedly saw material repairs and improvements under way which had been suggested or required by the inspector in charge. Most of the packing houses or parts of them are old, but all are being improved or renewed, often at heavy cost. This is especially true at Worcester.

I believe, however, that the inspectors in charge at both New Haven and Worcester are overworked, and ought to be given more assistants of a high grade, so that they themselves might be able to supervise their territory more efficiently. I believe, too, that they are underpaid and that it would add immensely to the efficiency of the service if the more responsible men at least were less hard worked and better paid.

In conclusion I may say that, cut short by my illness as my investigation of the meat inspection service has been, I am nevertheless deeply impressed with its excellence, its usefulness, and its efficiency. It is everywhere admitted I think that the United States meat inspection is far superior to any provided by the States, and that these constantly look up to it as a model toward which they are striving. I believe that in this they are right, and that if the service could be strengthened and increased, it would be even more satisfactory than it now is.

WM. T. SEDGWICK.

REPORT OF DRS. RAVENEL AND MOORE.

The undersigned, who were appointed by you in July, 1913, to investigate and report upon conditions in meat-packing establishments under Federal inspection, have the honor to submit the following report:

In your letters of appointment you said:

> With a view to safeguarding public health and maintaining the highest degree of efficiency in the meat-inspection service of this department, it is my desire that you report directly to me fully and frankly the conditions as you find them at the various packing establishments, together with such recommendations looking to the improvement of the service as in your judgment may seem best.

Dr. Moore was directed by you to investigate the work at New York and Buffalo, N. Y., and Philadelphia and Pittsburgh, Pa., and Dr. Ravenel that at Chicago, Ill., Indianapolis Ind., Milwaukee, Wis., and St. Paul, Minn.

We proceeded independently to investigate the establishments and the inspection service at the places assigned to us. Our inspections were made unannounced. As far as possible introductions were avoided, and we have reason to believe that for the most part the members of the meat-inspection force did not know that we were anything more than casual visitors. Certainly the majority of them did not know our names until afterward and many not at all.

As a result of our observations and study we unite in the conclusions and recommendations which follow. This report deals with the inspection as a whole rather than with the details of the work in the various places. Following out the two principal ideas set forth in our letters of appointment, we found in general that—

1. The methods laid down in the regulations are sufficient for insuring wholesome meats and for the protection of the public health.
2. These regulations are honestly and efficiently carried out.

INSPECTORS.

For a number of years past we have come into contact with a large number of the men engaged in the Federal meat-inspection service, and in the prosecution of our investigations we have studied them as carefully as possible from every standpoint. We are convinced that as a class they are an earnest and conscientious set of men, showing a commendable sense of responsibility to the service and to the public.

In each of the cities the inspector in charge was found at work on the problems of his station. The veterinary and meat inspectors were at their respective places doing in a careful manner the work in hand. In no instance was the inspector absent when the work or the regulations required his presence. It is gratifying to be able to state that the veterinary and meat inspectors were found to be men interested in their work and of a personal appearance that bespeaks their best efforts in the service. In fact, they all seemed to be competent and to understand thoroughly their duties.

The monthly meetings of the veterinary and meat inspectors that are held at the different stations by the inspectors in charge for the purpose of better qualifying the men are to be highly commended. Their meetings have a threefold significance, namely, (1) educational, (2) in stimulating a pride in the service, and (3) in fixing in the mind of the inspector the importance of his task.

ANTE-MORTEM INSPECTION.

The ante-mortem inspection is usually made on the premises of the slaughterhouses but at some of the large stations it is done in the stockyards. In the latter case, in addition to the ante-mortem inspection under the meat-inspection law, there is usually an inspection under the quarantine law, at the time of unloading or soon afterwards, of all animals received at the yards. Under these circumstances there is a double and sometimes a triple ante-mortem inspection.

With the funds available it is manifestly impossible to employ men enough to detect any but the more obviously diseased animals in the yards. The significance of ante-mortem inspection has been exaggerated. We regard this yard inspection as being of more importance to the animal industry than to human health, since all of these animals, if slaughtered in houses which are under Federal inspection, undergo the regular detailed post-mortem examinations before being passed for food.

POST-MORTEM INSPECTION.

In each of the packing houses the post-mortem examinations were being made according to the regulations for passing or condemning carcasses. In no instance did we detect any neglect on the part of the inspector in carrying out the regulations. The condemned carcasses or parts of carcasses were taken charge of by the inspectors and tanked as soon as the killing stopped, or they were placed under lock to be tanked later. There seemed to be a clear understanding on the part of the veterinary inspectors of the rules regarding the condemnation of carcasses. No infringement of the regulations on this subject was observed. The meat inspectors were likewise careful in their observance of the regulations relative to the inspection and condemnation of tainted, spoiled, or sour meats. We believe this inspection is thorough and sufficient to insure safe and wholesome meat.

In the newer houses the facilities for the post-mortem inspection as regards space, light, etc., are good. In some of the older houses, however, the business has increased beyond the normal capacity, and in these the position of the inspector, the space allowed, and the lighting were not satisfactory.

BUILDING, EQUIPMENT, AND SANITATION.

Regulations pertaining to the cleaning of floors and utensils were carefully observed. It must be remembered that the killing and dressing of animals can not be done without more or less blood and dirt. It is the uniform practice to clean up thoroughly after each killing period, and at no time is an accumulation of filth permitted. The metal, glass, tile, or wooden tables that are used were clean, as well as the cans, trucks, and other utensils used in handling the viscera, meat, and meat products. The requirements regarding floors, walls, light, etc., present difficult problems. In many instances new buildings have been or are being constructed. These are high class in every respect. Especially noticeable were the excellent "retaining rooms" for the final inspection of carcasses, which have been or are being constructed at many plants. These are invariably spacious, well lighted, and equipped with every convenience for making a thorough final examination. Each room is furnished with a table, the top of which is movable and built on the plan of a treadmill. Under the table is a tank of hot water, and after each examination, by the turning of a handle, approximately one-half of the table is immersed in hot water and sterilized while the other part of the table is being used. Consequently there is no danger of carrying any infection from a diseased carcass to one which may be passed for food. They are also well supplied with tanks in which the inspector can sterilize his knife between examinations, and no neglect was observed on the part of any inspector in using these conveniences.

In contrast with these are the older houses. They were built when the business was small and before modern improvements now considered to be essential were known. In most instances they began as small buildings and were added to until they became large in area, low between floors, and necessarily not well lighted nor ventilated. Many of these have been improved to the point where they satisfy the technical requirements of sanitation. This being the case, it is impossible to find just ground upon which to demand demolition and rebuilding. It is in many instances financially impossible for the owners to rebuild at once. The elimination of this class of houses must be a process of evolution. In some cities the improvements suggested by the inspectors in charge and costing several hundred thousand dollars are in progress. With these improvements there is no reason why animals can not be slaughtered and their carcasses handled in a perfectly sanitary manner. It would seem that beyond this point refinements in construction and equipment will be brought about by competition and the necessity of efficiency in the business.

In our investigations especial attention was paid to the toilet facilities and to the rules and regulations concerning the care of them. There has been tremendous improvement in this regard. Many of the toilets are entirely separate from buildings in which work is done. In others they are part of the building but entirely disconnected from workrooms and have outside ventilation. The fixtures for the most part are modern and sanitary, and there is an abundance of water for flushing purposes. What has been said concerning the buildings applies also to the toilets. In the newer houses they are adequate and sanitary. In the older ones they are often deficient in these respects.

It is remarkable how much has been accomplished in bringing about sanitary conditions in the packing houses under Federal inspection since the law of 1906 went into effect. It is true that there are still many things to be done, but the spirit and the letter of the law are being observed in all of the establishments which we have inspected. This does not mean that perfection has been attained but rather that much progress has been made in overcoming the serious obstacles which confronted the enforcement of a satisfactory meat-inspection service. As the entire subject of meat inspection in this country is comparatively new, the improvements that have been made are actually greater than one would expect in the time. It is a case where teacher as well as pupils have had to learn. We have found procedures and equipment that were recommended a few years ago discarded for other and supposedly better methods and materials. To convince one of the great advances that have been made, it is but necessary to visit a local uninspected slaughterhouse and contrast the conditions found with those in Federal-inspected establishments.

SUGGESTIONS AND RECOMMENDATIONS.

The conditions found in the packing houses and branch establishments have suggested certain changes or modifications either in the regulations or in the procedure which it is thought might be beneficial to the service. In accordance with the request in your letter of instruction, the more important of these are set out below. However, the progress in the improvement of the service that is now being made should not be interrupted by changes of methods unless there is sufficient evidence that they will be beneficial. With this explanation, we submit the following:

1. *Sterilized meat.*—Because of honest differences of opinion relative to the extent to which a disease may exist in an animal and its flesh remain safe for human food, we recommend that a plan be adopted by which the carcasses of animals affected locally and moderately with tuberculosis, hog cholera, and other diseases and conditions, and that are now passed only for lard or tallow, can be sterilized with steam under the supervision of the inspector and sold as cooked meat. The process of sterilization would insure the wholesomeness of the meat, and a heavy waste of good food would be

avoided. This method has been followed for many years in Germany and Austria, where it is very welcome and has worked well. The meat is sold as second class at a lower price.[1]

2. *Hog cholera.*—If condemnations of all animals showing signs of hog cholera were strictly carried out, the money loss would be enormous. As a more definite knowledge of this disease and its possible bearing upon human health is desirable, we recommend that studies be carried out to determine at what stages of the disease or of convalescence the carcass of an affected animal is fit or unfit for food, and that the regulations be revised if necessary to accord with the results of such investigations.

3. *Inspectors in charge.*—The success of the service depends largely on their knowledge of the multitude of details in the various establishments, as well as upon their ability to handle tactfully the many difficult situations in connection with the packing houses. They must often plan the improvements to be made. It is important that the inspectors in charge should be thoroughly practical men and if possible well informed on methods of constructing slaughter and process houses. The improvements recommended should be followed by helpful suggestions and sometimes with detailed directions for the work. The chief inspectors whom we have met attribute much of their success in bettering the conditions of the slaughterhouses to their ability to plan the reconstruction work.

4. *Equipment, facilities, etc.*—In the improvements which are being made in the packing houses there seems to be a lack of uniformity in much of the equipment put in and in the changes being made relative to kind of floors, walls, paint, trucks, and material for making tables on which are handled meats, sausages, etc. We recommend a careful study of the various materials, paints, etc., to determine those best adapted for the needs of the service, as necessarily modified by climate and possibly other local conditions. The fairly extensive use of trucks made entirely of metal for meat products was observed. For most purposes these seem to be the most suitable and sanitary, and their more general use is recommended. Wooden trucks are permissible when made of hard wood and kept free from cracks and loose joints.

The attitude of the operatives with regard to cleanliness, self-respect, etc., is largely influenced by their surroundings. We feel that much good could be accomplished by requiring the construction of proper facilities in the houses which are now deficient, and insisting on proper care of them in use. Washbasins with hot and cold water should be provided outside the toilet rooms, on the working floor where the employee is in full sight not only of the superintendent but of other workers in that department. It is best to have washbasins both in the toilet rooms and outside. This arrangement now exists in several houses, and inspectors as well as the superintendents say that it is more effective in securing cleanliness than the plan of having basins or sinks within the toilet rooms only. In those houses which employ janitors this does not seem to be so necessary. We recommend the more general employment of janitors for toilet and dressing rooms.

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[1] Note by the Department of Agriculture.—This recommendation was adopted in the revised meat-inspection regulations (B. A. I. Order 211).

Signs enjoining cleanliness and the observance of sanitary habits should be more generally used about official establishments. We recommend that the department specify signs of uniform style for this and other purposes.

Roller towels should not be used.

It is suggested that packers be required to have laundry facilities for the outer clothing of employees where they employ 15 or more men. The securing of clean clothing for the workmen and the arranging of suitable dressing rooms and lockers and keeping them clean are very important.

5. *Grading system.*—From what has been said above, it is evident that the slaughter and packing houses might be divided into several grades, ranging from those in which the buildings, equipment, and methods are first class in every respect, down to those which are unsatisfactory in one or all of these points, but which can not be justly condemned entirely. Under the present system the Government gives the same certification to the products of all these establishments. We consider this unfair to the consumer as well as to the first-class establishments. We therefore recommend the adoption of a scoring system similar to that now employed in grading dairies. We believe that this will go far toward removing the present unfairness, and will also exercise a most beneficial and stimulating effect on all classes of houses, and make it easier for the Federal inspection service to bring about the desired betterments in the poorer houses.

6. *Kosher killing.*—While it may be necessary to permit the methods of killing animals required by the religious rites of the Jewish people, it is suggested that as many as possible of the cruelties of the Kosher killing be abolished. It would seem that more humane methods could be followed and still not infringe upon the Mosaic laws. In Boston, we are told, much has been accomplished in this direction.

7. *Committee on improvements.*—The improvement of the packing houses and the establishing of a satisfactory system of inspection must of necessity require much time. The best arrangement of equipment, the most desirable materials to be used, and many other things pertaining to the packing-house business are as yet known only in part. Until more definite knowledge on these subjects is acquired, the best possible conditions can not be attained. For this reason we recommend that a committee be appointed to study and to try out various suggestions to improve the service. It is difficult to see how certain details can be effectively improved unless there is some provision for ascertaining what is the best to be recommended.

8. *State and municipal inspection.*—The criticism of the Federal meat-inspection service that is often made comes in the form of this inquiry: "Why should the Government spend so much money for meat inspection and be so severe with the packers when they kill but 60 per cent of the meat consumed, and when the other butchers can kill and sell what they like and in as filthy a place as they choose?" To overcome this, it is suggested that the department present to the proper State and municipal authorities a statement of fact with the recommendation that each State establish a meat-inspection service to safeguard its people against unwholesale meat. It is believed that the good auspices of the Federal Government in this matter would encourage the States to do their part in this commendable work. We believe that the powers of the Government in this respect are not

generally understood. The Federal meat-inspection law applies solely to establishments engaged in interstate traffic and to meats which are handled in interstate trade. For these reasons the Federal authorities can not interfere with establishments the business of which is restricted to the State in which they are located. Because butchering is an unpleasant and more or less dirty task, the surroundings should be such as to counteract this to the greatest extent possible and to safeguard the product.

9. *Publication of facts.*—We have been reminded many times during our inspection work of the many criticisms that have been made of the Federal meat-inspection service. We have not been told by anyone outside of the service of the good work that is being done by the inspectors in safeguarding the people against bad and diseased meat and of the improvements they have brought about in handling meat and meat products. There is not a general understanding of what is being done, nor of the problems to be solved. The general public is not well informed concerning the prevalence of disease in food-producing animals, nor of the extent to which the diseases render the flesh of such animals wholesome or unwholesome. The problem which confronts the Federal meat-inspection service is to provide a safe and wholesome meat food supply which is within the financial reach of the people. While the esthetic side is important, a sufficient supply of safe meat food is a necessity. In order that this entire question may be placed before the people, it is recommended that the department encourage the publication of popular articles on meat inspection that will inform the public of the facts pertaining to diseased meat and the work that the department is doing. The truth should be known. It would bring relief to the skeptical and much credit to the Federal meat-inspection service.

MAZŸCK P. RAVENEL.
VERANUS A. MOORE.

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A BIOLOGICAL METHOD FOR THE CONTROL OF DRACONTIASIS

By V. N. MOORTHY, B.SC., M.B., B.S., D.P.H., D.T.M.
and
W. C. SWEET, M.D., DR.P.H.

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In two earlier articles (Moorthy, 1932 and 1932*a*) reference was made to the probable usefulness of certain species of fish in the control of dracontiasis, due to their habit of feeding on cyclops and guinea-worm embryos. This biological method has been in use in the Chitaldrug district of the Mysore State since 1931 and this report covers observations on its utility as a practical field measure for the control of guinea-worm disease.

A survey of the Chitaldrug district made in 1929 showed that about 250 out of 1,400 villages depended entirely on step-wells for their water supply and that 112 of these villages had dracontiasis to a greater or lesser degree. In 1935 only 25 villages showed cases of this disease. Some of this decrease was undoubtedly due to other causes but the methods adopted for control were the following :

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* The work here reported was begun by the Mysore State Department of Health and continued with the support and under the auspices of the Department of Health, Government of Mysore, and the International Health Division of the Rockefeller Foundation.

1. Certain of the step-wells were converted into draw-wells by enclosing them with a parapet wall after providing a platform from which water could be drawn.
2. Provision in villages of new draw-wells.
3. Fortnightly treatment of step-wells with lime, perchloron or copper sulphate during the transmission season, from December to May.
4. Stocking step-wells with species of cyclopedocidal fish.

The first two measures mentioned are permanent and result in complete control of guinea-worm disease when they are effectively introduced. No other control methods should be considered as anything but temporary substitutes for these permanent measures. However, the conversion of step-wells and the provision of draw-wells are expensive and sometimes ineffective due to village prejudice and to the quality of water supplied by the new well.

The chemical treatment of step-wells is temporary in its effects (Moorthy, 1932*a*), and expensive in chemicals and staff, while the use of certain species of fish has been found to be effective, cheap, more permanent, and frequently popular with villagers.

Early field and laboratory observations

During early field studies in the Chitaldrug district certain observations were made which led directly to the trial of fish as a control method. The village of Kelgote, discussed later, gave a demonstration of the usefulness of fish, as did four other villages in which dracontiasis had disappeared following floods which had stocked the step-wells with small species of fish. In another village the drying up of one step-well with the consequent use for eight years of another well, naturally stocked with fish, led to the disappearance of guinea-worm disease until the original step-well was

Step-well A. Kelgote.

again put into use. It was also observed that no village in which the step-well contained these small species of fish had dracontiasis and that the density per dip of copepods in these wells was much lower than in wells with no such fish.

From specimens of fish collected in step-wells of the Chitaldrug district, Dr. S. L. Hora of the Indian Museum identified 16 different species (Hora, 1936). The following six species were found to be of use in guinea-worm control :

1. *Barbus (Puntius) puckelli.*
2. *Barbus (Puntius) ticto.*
3. *Lepidocephalocythys thermalis.*
4. *Rasbora doniconius.*
5. *Barbus sophore.*
6. *Barbus chola.*

Step-well A2, Medikerepura.

To these fish have since been added a species of Gambusia, imported from Italy, which has also been found useful. All of these species of fish feed on such copepods as cyclops, daphnia, cypris, and diaptomus, both under laboratory and field conditions, although *B. puckelli* and *B. ticto* are the most active in this respect. The Barbus species, *L. thermalis,* and Gambusia also feed on guinea-worm embryos under laboratory conditions although these embryos emerge weakened but alive in the fæces of all except puckelli. *L. thermalis* is a bottom feeder and commonly lies buried in the mud so that its intestinal contents contain many early forms of copepods and various types of ova; it is possibly most useful in destroying the ova and early forms of cyclops. Gambusia used alone for control allows wide variations in the density of copepods, depending on the presence or absence of young fish, but is especially effective as a species in lowering the density of diaptomus. The use of all these species of fish together makes an ideal combination and with their presence in a step-well the density of all copepods, including cyclops, remains very low.

Any species of fish to be useful in dracontiasis control should feed on and digest copepods, especially cyclops, should be a prolific breeder, and should have its breeding season just before or coincident with the guinea-worm transmission season. The use of one species of bottom feeder is apparently an advantage. No reliable information is available as to the distribution in India of the species of fish already mentioned but it is quite possible that other species in other parts of India would fulfil these requirements.

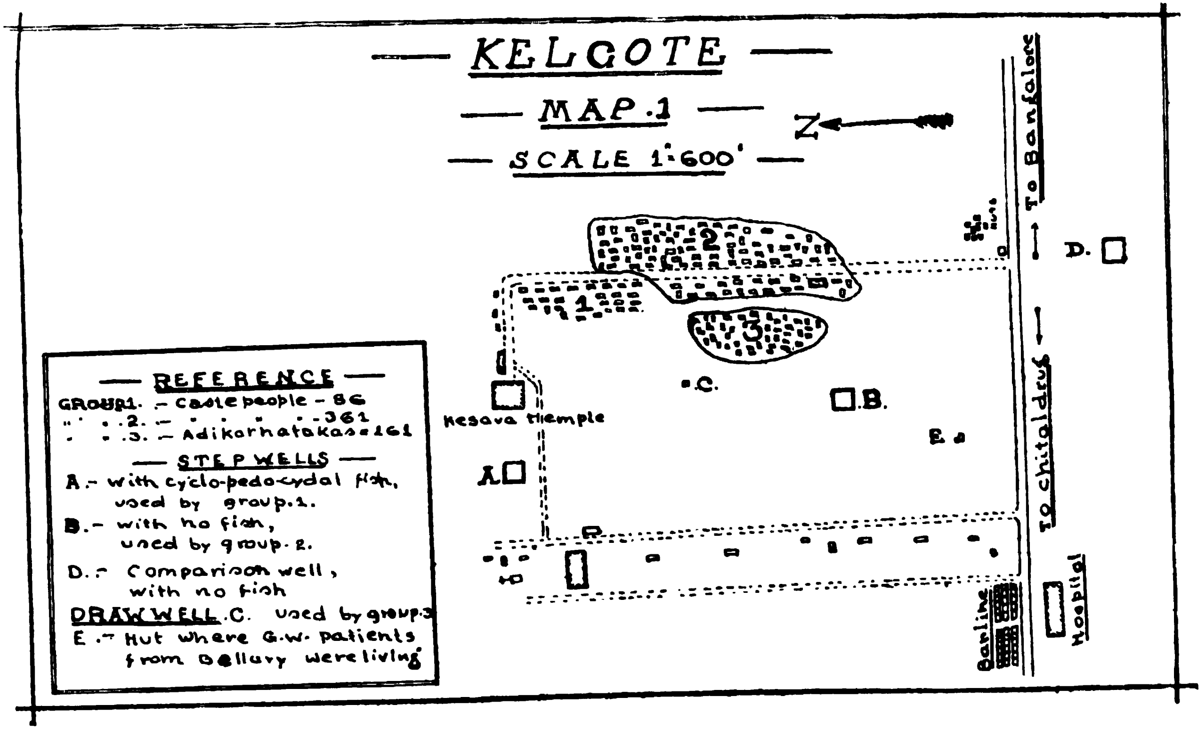
The method of counting cyclops and other copepods in water should be described. Collections are made with a linen tow net ending in a glass tube. The net has a rod six feet in length and the same net is used for all counts. From 100 to 150 dips are taken in various parts of the well and the copepods collected in the glass tube are separated visually by pipettes into three clean bottles labelled 'cyclops', 'diaptomus', 'others'. The copepods are then killed with formalin and later counted under a microscope in the laboratory. The average number per dip can then be calculated.

Kelgote village (map 1)

Kelgote, with a population of 608, can be divided into three groups according to the source of water used. One end of the village, 86 people, used water from step-well A, which contained most of the species of small fish mentioned before; these had been naturally introduced and there were histories of only sporadic cases of guinea-worm infection amongst this group. The second division, 361 people, used water from step-well B, containing no fish, and histories indicated an average annual occurrence of 46 dracontiasis cases, while the 161 *adikarnatakas* had no history of infection and used water from draw-well C.

After thorough treatment with copper sulphate and perchloron, specimens of each species of fish present in well A were transferred to well B on 30th May, 1931, and careful counts of copepods from B and from a comparison step-well D were kept in following years. Step-well D contained no fish and the water was not used for drinking. The fish in well B multiplied rapidly and since early 1932 the number of cyclops per dip has never exceeded 10; the water of well D has continued to yield from 680 to 1,200 cyclops per dip.

Among the people using water from step-well B there were 22 cases of dracontiasis in 1932, 4 cases in 1933 and no cases since (up to June 1936). This occurred in spite of the presence in a hut (E, map 1), near the step-well, in 1935 of two guinea-worm cases from Bellary who were seen actually infecting the

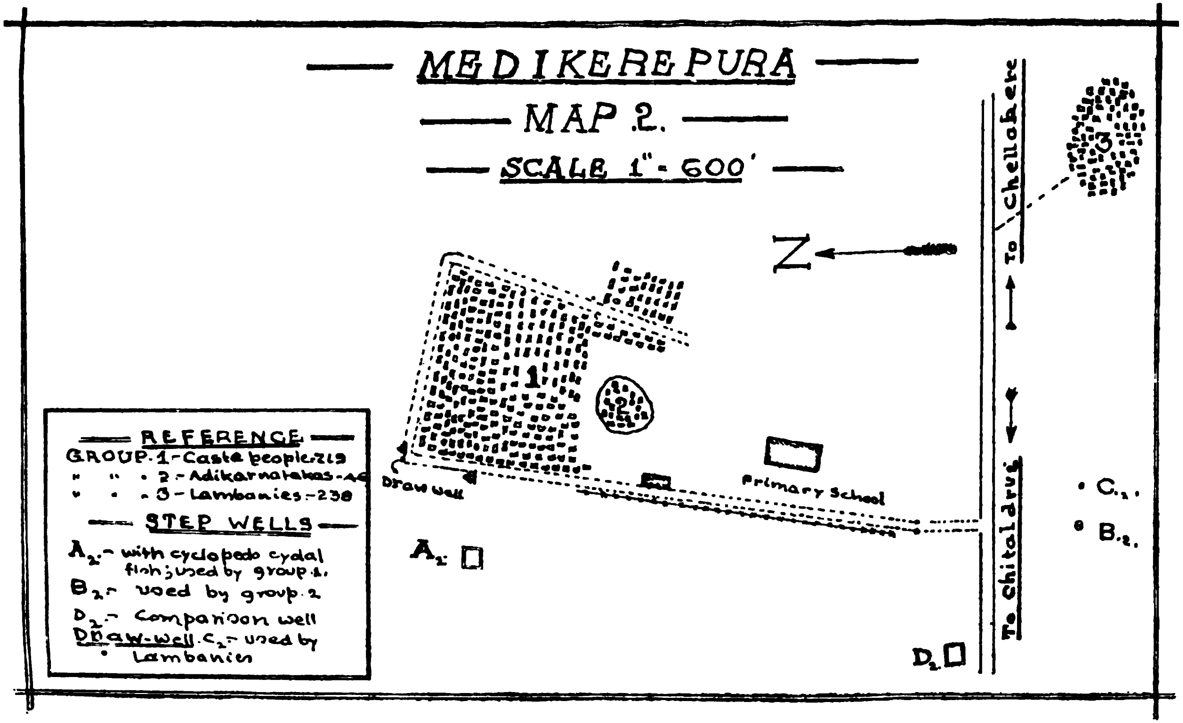

KELGOTE
MAP.1
SCALE 1:600'
N
To Bangalore
To Chitaldrug
D.
Hospital
Banline
2
1
3
C.
B.
E.
Kesava temple
A
REFERENCE
GROUP1. – Caste people – 86
" " .2. – " " " " – 361
" " .3. – Adikarnatakas = 161
STEP WELLS
A. – with cyclo-pedo-cydal fish, used by group.1.
B. – with no fish, used by group. 2.
D. – Comparison well, with no fish
DRAW WELL C. used by group 3
E. – Hut where G.W. patients from Bellary were living

water with embryos during the transmission season.

Medikerepura village (map 2)

Medikerepura village has a population of 1,003 persons, made up of 719 caste people, 46 *adikarnatakas*, and 238 *lumbanys*. The majority of the caste people use water from step-well A_2, since the water of their draw-well is brackish, and their history indicated an annual average of 113 cases of dracontiasis. The *adikarnatakas* use water from a shallow step-well in the fields, B_2, and gave a history of about 22 cases per year, while the *lumbanys* use water from a draw-well, C_2, within 30 yards of B_2, and are completely free from this infection. Another step-well, D_2, was used for comparative purposes.

The step-well A_2 was thoroughly treated with perchloron on 3rd February, 1934, and was stocked with 100 specimens each of *B. puckelli, B. ticto, B. chola, B. sophore* and *L. thermalis* on the 26th February. Step-wells B_2 and D_2 received no chemical treatment nor were fish introduced. The initial cyclops count of well A_2 was 560 per dip, a count which was reduced to zero four days after the perchloron treatment and had been restored to 28 per dip on the day the fish were introduced. Large numbers of young fish were first seen on 18th June, 1934, when the cyclops count was 87 per dip. On 25th March, 1935, the count was 10 cyclops in 50 dips and since then there has been some variation but no count has been above 18 per dip. Counts in B_2, the *adikarnataka* well, have never been below 240 cyclops per dip and in C_2 never below 428.


MEDIKEREPURA
MAP 2.
SCALE 1" - 600'
N
To Chellakere
To Chitaldrug
3
1
2
Primary School
Draw well
A₂
B₂
C₂
D₂
REFERENCE
GROUP 1 - Caste people - 219
" " 2 - Adikarnatakas - 46
" " 3 - Lambanies - 238
STEP WELLS
A₂ - with cyclopedo cydal fish; used by group 1.
B₂ - used by group 2
D₂ - Comparison well
Draw-well. C₂ - used by Lambanies

Against the average of 113 cases of dracontiasis among the 719 caste people there were eight cases in 1935 and no cases at all in 1936. Amongst the 86 *adikarnatakas,* whose step-well was not treated in any way, there were 14 cases in 1935 and 18 cases in early 1936, as compared with the annual average of 22 cases previous to 1934. The *adikarnataka* step-well was stocked with fish in June 1936.

The very marked reduction of infection in this village one year after the introduction of fish and its complete disappearance thereafter were probably due to the fact that the fish were introduced early in the guinea-worm transmission period and just at the breeding season of *B. puckelli.* Neither of the conditions was true in Kelgote village where the initial reduction was not so marked and cases occurred in the second year.

Routine control measures

Since 1934 fish have been introduced into step-wells in 35 infected villages with the result, where careful records have been kept, that guinea-worm disease has disappeared in six and been markedly reduced in four. In certain of these villages the fish have not survived and this difficulty will undoubtedly be met with occasionally in other areas where this method is tried. Investigation has shown that this may be due to the bailing out of water to remove silt, to the drying up of the well in summer, to unexpected treatment with perchloron or overdoses of potassium permanganate, or to the catching of the fish for eating when the water is low. It is also probably true that certain waters on account of their chemical or biological peculiarities will not support these fish.

The first measure in routine control of guinea-worm disease by fish is the establishment of hatcheries from which the various species will be always available. In the Chitaldrug district this has been done in 73 *taluk* and *hobli* headquarters. It should also be noted that each successfully-controlled step-well can become a hatchery for the supply of fish to neighbouring villages.

Any step-well to be stocked with fish should be previously treated with perchloron (3 lbs. to 100,000 gallons) until it is free of cyclops. Should this measure result in odour due to decaying organic matter, a small dose of potassium permanganate will remedy matters. The perchloron, if used properly, will kill many of the predaceous species of fish and leave the well free for the smaller species used in control. It is best to encourage the villagers to bail out the wells and remove silt before the treatment with perchloron is used.

About 100 specimens of each species of fish used for control should be freed in the well about one month after the dosing with perchloron. The fish may be transported in large cans with mesh tops either by lorry or cart, avoiding shaking as much as is possible.

A small staff of one or more sanitary inspectors, depending on the size of the area to be covered, and the necessary peons should supervise the stocking of wells, check up the breeding and presence of the fish in the wells, and record results of the work. It should be noted that this method can be used not only in infected villages but also in other areas in which the disease occurs sporadically, due to the use of step-wells for a drinking water supply to which wandering cases of dracontiasis have access.

The custom of keeping fish in the drinking water supply is apparently widespread in India so that the fish control measures fit in with an existing habit. From our experience it is not difficult to teach the villager the proper species to use and he rapidly becomes an enthusiastic and vigilant co-operator in the control of his own step-well. In this connection, it is of some interest to note that, unlike Gambusia, the Barbus species used in control of cyclops will cluster around the submerged portions of the body of people using the step-well and pull at hairs and loose epidermis enthusiastically. This habit has been noted by the village people and it is made use of in some areas as a treatment for certain types of skin diseases and ulcers.

The fish control of dracontiasis is more permanent, more efficient and much cheaper than the usual chemical methods of control but it should be again emphasized that the abolition of step-wells is the only permanent and fool-proof measure for the control of this disease.

Summary

The control of dracontiasis by the use of certain small species of fish which ingest cyclops and other copepods is suggested, and the freeing of guinea-worm infection of two villages in the Chitaldrug district of Mysore State is described. Routine methods in use for fish control are mentioned and it is claimed that these methods are more permanent, more efficient and cheaper than the usual chemical methods of control. It must, however, be emphasized that the abolition of step-wells is the only permanent, fool-proof, method of control.

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THE INDIAN MEDICAL GAZETTE

A Record of Medicine, Surgery, Public Health and Medical News, Indian and European, with special reference to Diseases of Tropical Countries

Editor:—L. E. NAPIER, M.R.C.P. (Lond.)
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Moorthy, V. N.
1937. [Camallanus sweeti n. sp., a
new species of Camallanida
(Nematoda).]

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Reprinted from THE JOURNAL OF PARASITOLOGY, June, 1937, Vol. 23: No. 3,
pages 302–306

CAMALLANUS SWEETI N. SP., A NEW SPECIES OF CAMALLANIDAE (NEMATODA).

While conducting investigations on dracontiasis in the Chitaldrug district (Mysore State), South India, it was found that specimens of cyclops collected from one of the step wells in Chitaldrug town were found infected with *Camallanus* larvae under natural conditions. Acting upon a suggestion from Doctor W. C. Sweet, a careful search for the adult worms was made in five of the larger species of fish present in the same step well, of which only *Ophicephalus gachua* (Ham) has been so far found infected.

Out of 148 specimens of *Ophicephalus gachua* 142 or 95.9 per cent were found to be infected with adult *Camallanus* worms in their intestines. The total number of worms present in each of these infected specimens varied from 25 to 180, the males being found usually in larger numbers than females. The immature females and males were found usually in the first half of the intestine, the mature females containing embryos being found in the last half of the intestine.

This nematode appears to be a new species and for it the name *Camallanus sweeti* is proposed in honor of Doctor W. C. Sweet of the Rockefeller Foundation, Mysore State, India, to whom the writer is greatly indebted for the very valuable suggestions, help, and encouragement given.

Camallanus sweeti n. sp.

Description: Stoma, 0.06 to 0.07 mm. long; consists of paired jaws and well developed, wide, chitinous, ring that separates the jaw from the oesophagus (fig. 2); nine longitudinal ridges, beaded in appearance, and of about the same length extend from anterior end to upper margin of chitinous ring; oral opening, wide and surrounded by internal circle of two pairs of small papillae and external circle of two pairs of comparatively more prominent papillae; amphids, indistinct (fig. 3); trident, with median process longest, about 0.046 mm., and two submedians of about equal length, each measuring about 0.025 mm. (fig. 1); two quadrilateral chitinous plates, situated at anterior margin (fig. 2).

Female: 3.2 to 5.5 mm. long by up to 0.15 mm. wide; cuticular striations, fine, not over 4 μ apart; oesophagus, anterior muscular portion, 0.32 to 0.42 mm. (from anterior extremity to commencement of glandular portion), posterior glandular portion, 0.4 to 0.52 mm. (from commencement of glandular portion to extreme end of it); nerve ring, at junction of proximal one-third with distal two-thirds of muscular portion of oesophagus; excretory pore, about 0.16 mm. from anterior extremity (fig. 6); vulva, 2.0 to 3.0 mm. from anterior end, conspicuous and provided with well developed prominent lips; in fertilized females containing embryos, posterior lip pushed to one side by overhanging anterior projection making prominent protrusion on one side of body; in young immature forms such projection not usually found; vagina, narrow and runs back posteriorly to about 0.3 mm. (fig. 7); tail with three mucrones at tip; length varies from 0.05 to 0.07 mm.; in immature forms, the mucrones are very prominent, mediodorsal being noticeably stouter and longer than two ventro-laterals (fig. 8); in mature forms comparatively less prominent and of about same size (fig. 9).

Male: 3 to 3.9 mm. in length and up to 0.13 mm. in width; oesophagus, anterior muscular portion, 0.31 to 0.38 mm. in length (from anterior extremity to commencement of glandular portion); posterior glandular portion, 0.38 to 0.44 mm. in length (from commencement of glandular portion to extreme end of it); tail 0.05 to 0.063 mm. in length; in immature forms mucrones are present at the tip as in females; in mature forms, only ventro-laterals prominently seen, median one considerably reduced in size and seen as a small papilliform projection (fig. 4); genital papillae, 13 to 15 pairs: preanal, 4–6 pairs; circumanal, 2 pairs and postanal 7 pairs; num-

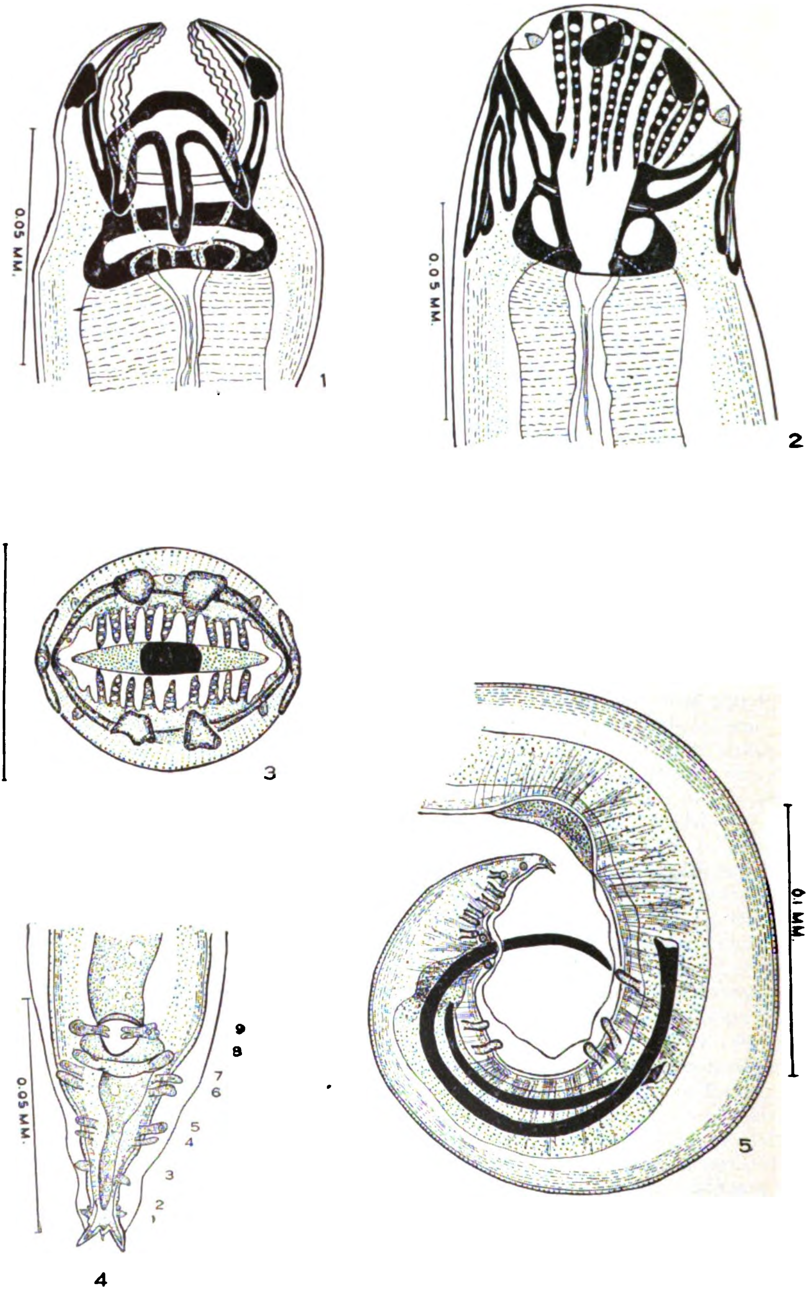
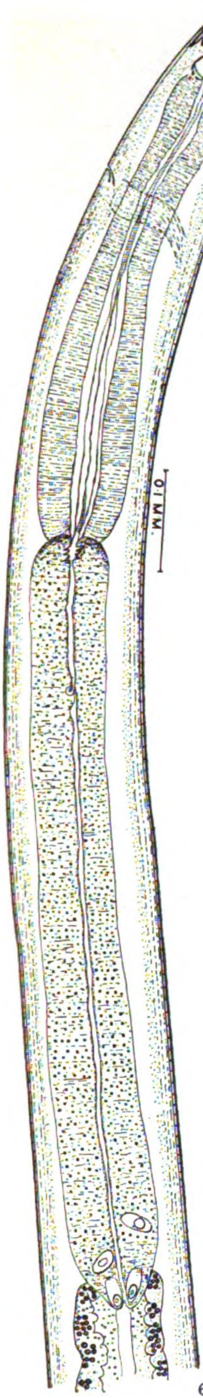


PLATE I

Camallanus sweeti, n. sp.

Fig. 1. Head of female, median view.
Fig. 2. Head of female, lateral view.
Fig. 3. Head, en face view.
Fig. 4. Tail of male, ventral view.
Fig. 5. Tail of male, lateral view.



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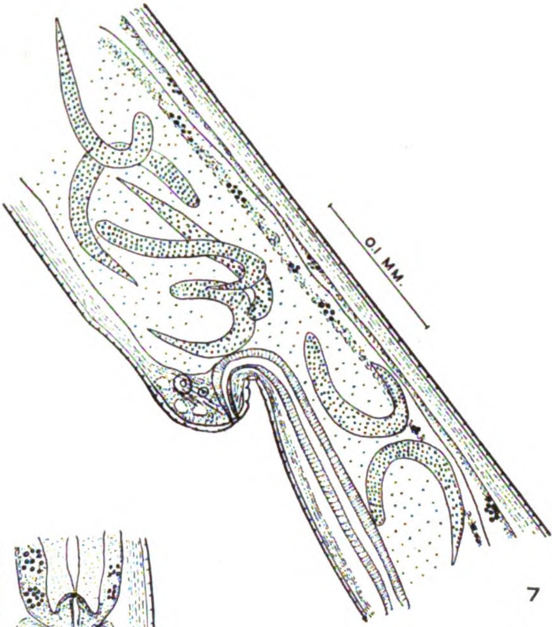

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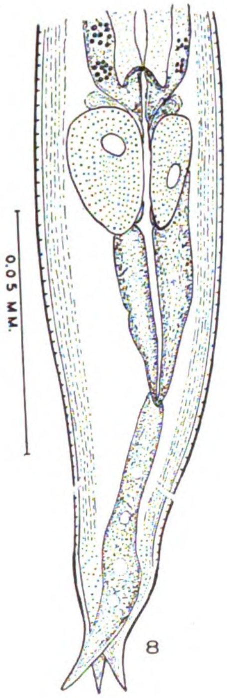

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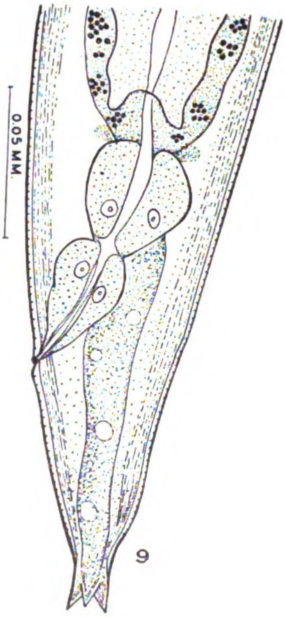

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PLATE II

Camallanus sweeti n. sp.

Fig. 6. Female, oesophageal region.
Fig. 7. Vulva of an adult female, lateral view.
Fig. 8. Tail of female, ventral view.
Fig. 9. Tail of female, lateral view.

bering from the posterior extremity, pairs 1 and 2, lateral and in a group; pair 3, ventro-lateral and isolated; pairs 4 and 5, ventro-lateral and in a group; pairs 6 and 7, ventro-lateral and in a group; pairs 8 and 9, circumanal and isolated; preanal papillae variable, 4–6 pairs, subventral to ventro-lateral; in majority of specimens 5 hairs present; spicules, unequal; right, longer and more prominent, measuring 0.21 to 0.30 mm. in length; left, comparatively very much more slender and measures 0.1 to 0.18 mm. length; a sucker-like organ situated at about 0.32 mm. from the posterior extremity (fig. 5).

Discussion: Camallanus sweeti resembles, to a certain extent, both *Camallanus melanocephalus* (Rudolphi, 1819) and *Paracamallanus cythopharynx* (Baylis, 1923), in its having a relatively well developed wide chitinous ring that separates the jaws from the oesophagus. But it differs from them in size and shape of the chitinous ring, and in the spicules being definitely unequal, the right one being nearly twice as long as the left. In *C. melanocephalus* the spicules are subequal and in *P. cythopharynx* the spicules have not been detected. *C. sweeti* appears to be a transitional form between the genus *Camallanus* and *Paracamallanus.* It has been found that the larval forms of this species pass through a stage having a stoma very much similar to that found in the adult in the genus *Paracamallanus;* but in the adults the stoma resembles more that of the genus *Camallanus* than of *Paracamallanus.* This observation suggests that the presence or absence of a large chitinous buccal cavity is not a satisfactory generic character and casts some doubt as to the necessity of keeping *Paracamallanus* as a separate genus.

Life history: The complete life history of *Camallanus sweeti* is at present being worked out and the results will be published in a subsequent paper. From the observations so far made, this parasite appears to require the intervention of two intermediate hosts, the cyclops (*Cyclops leuckarti*) and a smaller species of fresh-water fish (*Barbus puckelli* or *Lepediocephalocythys thermalis*), before final development can take place in the definite host (*Ophicephalus gachua*). The larvae undergo initial development in the body cavity of cyclops which become infected by feeding on larvae liberated from the adult worms. Further development of the larvae takes place in the intestine of the fresh-water fish when they feed on these infected cyclops. The larvae, after undergoing the preliminary developmental changes in the second intermediate host, remain encysted in the intestinal wall, and the infection of the final host takes place by its feeding on these smaller species of infected, fresh-water fish.

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Acknowledgement is made to the International Health Division of the Rockefeller Foundation, for having granted the fellowship which made this work possible. The writer is greatly indebted to Drs. W. W. Cort, G. F. Otto, and P. Parthasazathy for the helpful criticism and advice given in the course of this work. To Dr. B. G. Chitwood the writer wishes to express his gratitude for very valuable help and guidance. This paper is a contribution from the Department of Helminthology, School of Hygiene and Public Health, the John Hopkins University, Baltimore, Md.—V. N. Moorthy, *Fellow of the Rockefeller Foundation from Mysore State, Department of Health, Bangalore, India.*

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38. Capillaria infection in Fish.

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CAPILLARIA INFECTION IN FISH

While examining the intestinal contents of fishes used in the biological control of dracontiasis, it was observed that some of them were naturally infected with an early-stage capillarid larva. A brief account of the larva is given in this paper.

Of the several species of copepodocidal fish examined from different freshwater ponds in the Chitaldrug District, Mysore State, India, only *Barbus puckelli* (62 %), *Barbus ticto* (22 %), and *Lepidocephalichthys thermalis* (15 %) have been found naturally infected with the *Capillaria* larva, which was usually found imbedded in the mucous coat or encysted in the peritoneal layer of the midgut.

The description and measurements given are of the larva preserved, stained, and mounted by the author's method (Moorthy, 1937, J. Parasitol., 23: 100–102).

Description: Body, 0.60 to 0.76 mm long by 0.020 to 0.024 mm wide; narrow anteriorly and widening gradually posteriorly (fig. 1). Spear present; imperfectly chitinized, its length equal to about one-third body width in spear region (fig. 2). Nerve ring 0.052 to 0.070 mm from anterior extremity. Esophagus 0.50 to 0.62 mm long, occupying nearly six-sevenths of anterior portion of body and lying to one side of stichosome for a short distance anteriorly and then superficial to it (fig. 1). Esophageal lumen very narrow and indistinct anteriorly, widening gradually posteriorly and very distinct at its junction with intestine. Prominent cell with a conspicuous nucleus, probably a coelomocyte, present at junction of esophagus with intestine (fig. 4). Stichosome consisting of a single row of cells 0.46 to 0.55 mm in length, commencing about 0.05 to 0.10 mm from anterior end and extending slightly beyond junction of esophagus with intestine; first cell longest and slightly bilobed at its anterior extremity (figs. 1 and 2). Cells in anterior half of stichosome, varying in size and nature of contained granules; shorter cells containing coarse granules regularly alternate with longer cells containing comparatively fine granules (fig. 3); posteriorly the cells are uniformly small and contain coarse granules. Bacillary band lateral, extending along entire length of larva (fig. 3), its width equal to about one-third that of body. Intestine very short, being only about one-seventh of body length; it consists of large numbers of cells containing transparent globules and granules. Rectum 0.034 to 0.050 mm in length, thin-walled, narrow and tubular. Anus terminal. Posterior end rounded and slightly bilobed.

The size of the larva, the presence of single row of cells in the stichosome, the anterior portion of the body being considerably longer than the posterior portion, and the imperfect chitinization of the spear suggest that the larva is probably in the third stage of development. The presence of only third stage larvae, in some cases encysted in the intestinal wall, suggests that copepodocidal fish possibly act as second intermediate hosts; perhaps a copepod is the first intermediate host and a predacious fish, bird, or turtle is the definitive host.

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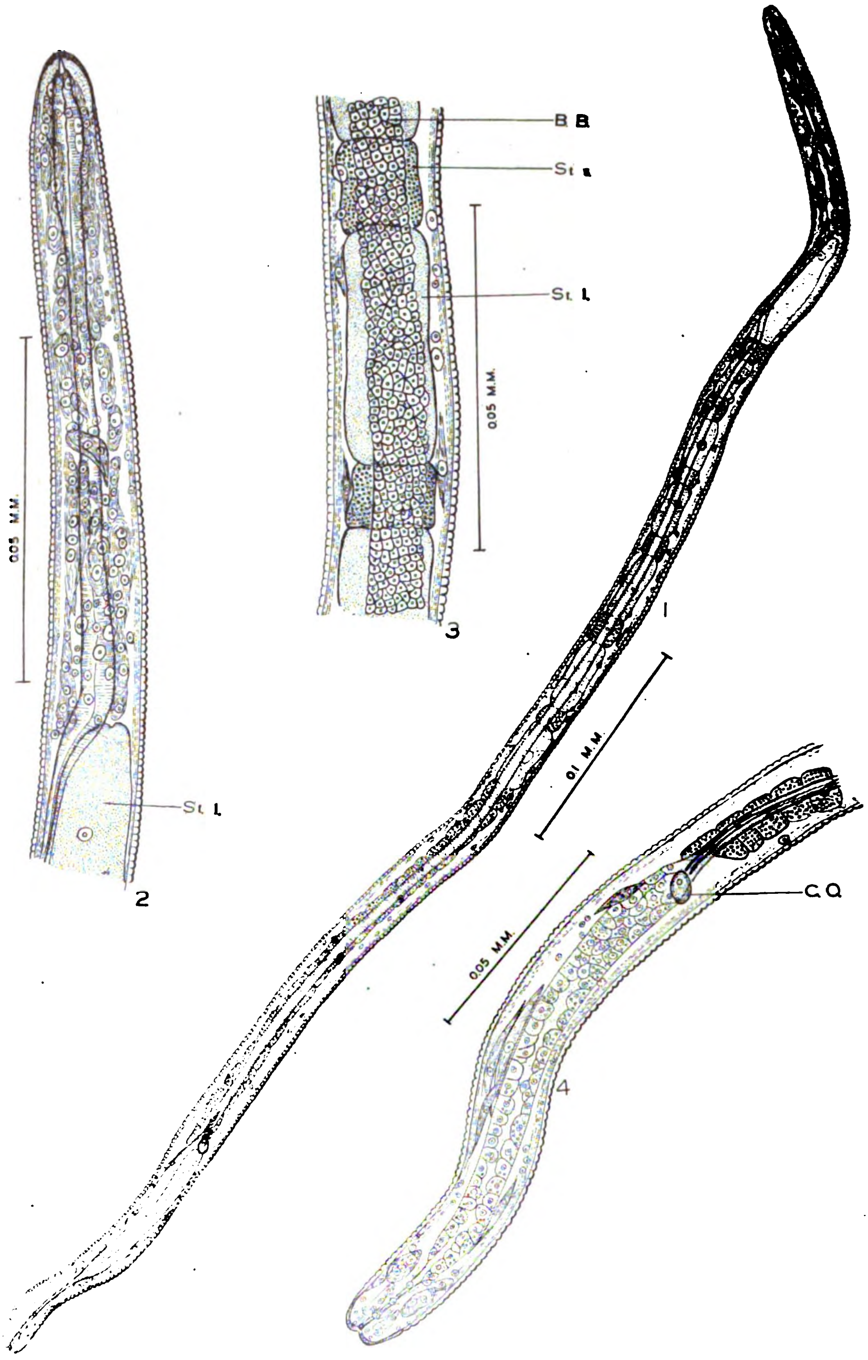
This paper is a contribution from the Department of Helminthology, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Md.—
V. N. MOORTHY, *Mysore State Department of Health, Bangalore, India.*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Capillaria larva

FIG. 1. Median view.
FIG. 2. Anterior portion of the esophageal region.
FIG. 3. Lateral view; shows the bacillary band, the short and long stichosome cells.
FIG. 4. Intestinal region, lateral view.

Abbreviations: St.l. = Long cell of stichosome
St.s. = Small cell of stichosome
C.O. = Coelomocyte
B.B. = Bacillary band

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GUINEA-WORM INFECTION OF CYCLOPS IN NATURE

By V. N. MOORTHY, B.SC., M.B., B.S., D.P.H., D.T.M.
and
W. C. SWEET, M.D., Dr.P.H.

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GUINEA-WORM INFECTION OF CYCLOPS IN NATURE*

By V. N. MOORTHY, B.SC., M.B., B.S., D.P.H., D.T.M.

and

W. C. SWEET, M.D., Dr.P.H.

During the course of field and laboratory studies on guinea-worm infection that have been carried on in the Chitaldrug district of the Mysore State since 1929, repeated unsuccessful attempts have been made to find naturally-infected cyclops in the step-wells of the area. Until 1935 the laboratory had been opened in March and closed in June, at the time when the largest number of dracontiasis cases were available, and all cyclops surveys had been made during these months. It was, however, possible to keep the laboratory open during the whole year of 1935 and until June 1936. Late in the former year a step-well used by the *adikarnatakas* of Medikerepura (Moorthy and Sweet, 1936) was selected for intensive study and early in 1936 naturally-infected cyclops were found in this well.

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* The work here reported was begun by the Mysore State Department of Health and continued with the support and under the auspices of the Department of Health, Government of Mysore, and the International Health Division of the Rockefeller Foundation.

Since cyclops must be infected by embryos emerging from the female worm shortly after the skin blister has opened, weekly dipping for cyclops was begun in the Medikerepura well from 18th December, 1935, when the first case of dracontiasis was found in the village. The step-well concerned is an open pit, about 8 feet in diameter and 18 feet in depth, in the fields about two furlongs from the village. It is not stone-lined but has irregular stone steps to the water-level on one side. The dipper used had a twelve-foot rod to which was attached a linen tow net ending in a glass tube and care was taken to make dips from all parts of the well and at varying depths below the surface of the water.

Specimens of cyclops collected from various step-wells of the Chitaldrug district were identified by Dr. Frederick Kiefer (personal communication) as belonging to four old species and one new one (Kiefer and Moorthy, 1935). Of these *M. leuckarti* and *M. hyalinus* are the most common species.

Mesocyclops leuckarti Claus.
Mesocyclops hyalinus Rehberg.
Mesocyclops decipiens Kiefer.
Paracyclops fimbriatus Fischer.
Microcyclops karvei Kiefer and Moorthy.

Of these species of cyclops only *M. leuckarti* and *M. hyalinus* were found infected in nature although all of them were susceptible in the laboratory and allowed full development of the guinea-worm larvæ.

The first natural infections of cyclops were found on 9th January, 1936, twenty days after the discovery in the village of the first dracontiasis case of the year and at a time when there were eight active cases. On that date the infection rate of the *M. leuckarti* examined was 4.2 per cent and of *M. hyalinus* was 2.1 per cent. The full findings of natural infections in these two species of cyclops, the only one found infected, are given in table I. The highest infection rate found at any examination was 4.6 per cent on 28th January, 1936.

Although *M. leuckarti* had the higher infection rate there were larger actual numbers of infected *M. hyalinus* in the well due to the preponderance of this species at this time of year. As far as transmission of dracontiasis was concerned *M. hyalinus* was the most active species in this village. In spite of careful search no infected cyclops were found after 10th March, 1936.

The usual village pot of water, holding about two gallons, was found by several examinations to contain on the average two infected cyclops at the height of the infection and in no instance was any naturally-infected cyclops found to have more than one guinea-worm larva.

Infections with guinea-worm larvæ were not found in fully-mature female cyclops bearing ovisacs but were most common in the younger adult females. The distribution of the infections according to the stage of development of the cyclops, as found among 1,302 mixed specimens of *M. leuckarti* and *M. hyalinus*, is given in table II.

TABLE I
Natural guinea-worm infection in cyclops

	Mesocyclops leuckarti			*Mesocyclops hyalinus*			Both species		
	No. exam.	No. inf.	Per cent	No. exam.	No. inf,	Per cent	No. exam.	No. inf.	Per cent
18th Dec., 1935 ..	282	0	0.0	452	0	0.0	734	0	0.0
23rd ,, ,, ..	260	0	0.0	408	0	0.0	668	0	0.0
4th Jan., 1936 ..	180	0	0.0	382	0	0.0	562	0	0.0
9th ,, ,, ..	94	4	4.2	334	7	2.1	428	11	2.5
14th ,, ,, ..	106	5	4.7	175	4	2.3	281	9	3.2
22nd ,, ,, ..	121	6	5.0	339	12	3.5	460	18	3.9
28th ,, ,, ..	155	8	5.2	260	11	4.2	415	19	4.6
8th Feb., ,, ..	146	5	3.4	301	6	2.0	447	11	2.5
24th ,, ,, ..	184	4	2.1	200	1	1.0	384	5	1.3
3rd Mar., ,, ..	162	2	1.2	198	1	0.5	360	3	0.8
10th ,, ,, ..	184	0	0.0	230	0	0.0	414	0	0.0
Subsequent examinations were all negative.									
TOTAL ..	1,874	34	1.8	3,279	42	1.3	5,153	76	1.5

TABLE II

Distribution of natural cyclops infections according to stage of development of the cyclops

Life stage of cyclops	Number examined	Number infected	Per cent
Young adult females	522	23	4.4
Immature males and females.	618	18	2.9
Mature males ..	122	4	3.2
Mature females with ovisacs.	40	0	0.0
All forms ..	1,302	45	3.7

As far as could be determined, the guinea-worm larvæ went through the same developmental changes in the body cavities of naturally-infected cyclops as they do in the case of laboratory infections. The possibility of transmission of dracontiasis by these naturally-infected cyclops was demonstrated by the finding at autopsy in dog no. 28 of 51 immature guinea-worms (Moorthy and Sweet, 1936). This dog was fed with 88 naturally-infected cyclops and died 67 days later.

Summary

After repeated unsuccessful attempts made in earlier years after the first of March, cyclops naturally infected by guinea-worm larvæ were found in a step-well in the Chitaldrug district of Mysore State in January and February 1936, at a time when there were in the village several cases of dracontiasis in the early stages. Although *M. leuckarti* had the higher infection rate, the actual number of *M. hyalinus*

infected was greater; this was due to its numerical preponderance. No infections were found in other species of cyclops and none of the infected specimens were fully-mature females bearing ovisacs; all infections were in the younger forms of both sexes. That the naturally-infected cyclops could transmit dracontiasis was demonstrated by the finding of immature guinea-worms at autopsy of a dog which died 67 days after a feeding of 88 naturally-infected cyclops.

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A NOTE ON THE EXPERIMENTAL INFECTION OF DOGS WITH DRACONTIASIS

By V. N. MOORTHY, B.SC., M.B., B.S., D.P.H., D.T.M.
and
W. C. SWEET, M.D., Dr.P.H.

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A NOTE ON THE EXPERIMENTAL INFECTION OF DOGS WITH DRACONTIASIS*

By V. N. MOORTHY, B.SC., M.B., B.S., D.P.H., D.T.M.

and

W. C. SWEET, M.D., DR.P.H.

VARIOUS workers have attempted to induce guinea-worm infection in laboratory animals but Leiper (1906), who succeeded in giving this infection to monkeys, and Issajev (1935), who succeeded with dogs, have been the only ones to report success. The first part of this note concerns the finding of four fully mature female nematodes in the external tissues of a dog approximately one year after it had received feeds of cyclops infected with guinea-worm embryos and of such embryos freed, after full development, from infected cyclops.

The dog concerned, one of 28 experimental animals, was purchased in Bangalore (a non-endemic area), at the approximate age of two months, and was taken to a field laboratory in Chitaldrug, Mysore State, the centre of an extensive endemic dracontiasis area. At about the age of five months, and after preliminary tests and examinations, it was given its first feed of 22 infected cyclops on 6th May, 1935, subsequent to a period of eighteen hours' starvation; the cyclops were taken up in a pipette and squirted well back into the dog's throat. The next day the dog was allowed to lap water containing infective larvæ dissected out of 20 infected cyclops, and this was repeated on the 13th May, except that the released larvæ were squirted into the throat from a pipette. On the 14th May, 21 infected cyclops were slightly injured by pricking into the body cavity and were squirted into the throat. Subsequent feedings, using one of the above methods, were given on the 21st, 22nd, 23rd and 25th of May. This first series of infective feedings consisted of a total of 123 infected cyclops and the fully developed larvæ released from 40 infected cyclops. These cyclops were infected in the laboratory, about three weeks before being given in feedings, by guinea-worm embryos obtained by the use of ethyl chloride spraying of newly opened blisters in human cases of dracontiasis.

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* The work here reported was done with the support and under the auspices of the Government of Mysore and the International Health Division of the Rockefeller Foundation.

When guinea-worm embryos again became available early in 1936, and since the dog had shown few signs of infection, it was given two further feedings of 110 guinea-worm-infected cyclops on the 19th of March and 19th of April, 1936.

Subsequent to the eight infective feedings given in May 1935, the dog remained well until early in August of the same year when it developed digestive troubles and pustular skin eruptions. It recovered after injections of one c.cm. of omnadin on three successive days, followed by a one c.cm. milk injection on the fourth day, and remained apparently completely healthy until the following April.

This dog had an eosinophile count of 6.1 per cent on 10th March, 1935, and of 19.3 per cent on 9th April, 1936. Its highest eosinophilia was 35.0 per cent on 8th August, 1935. A control

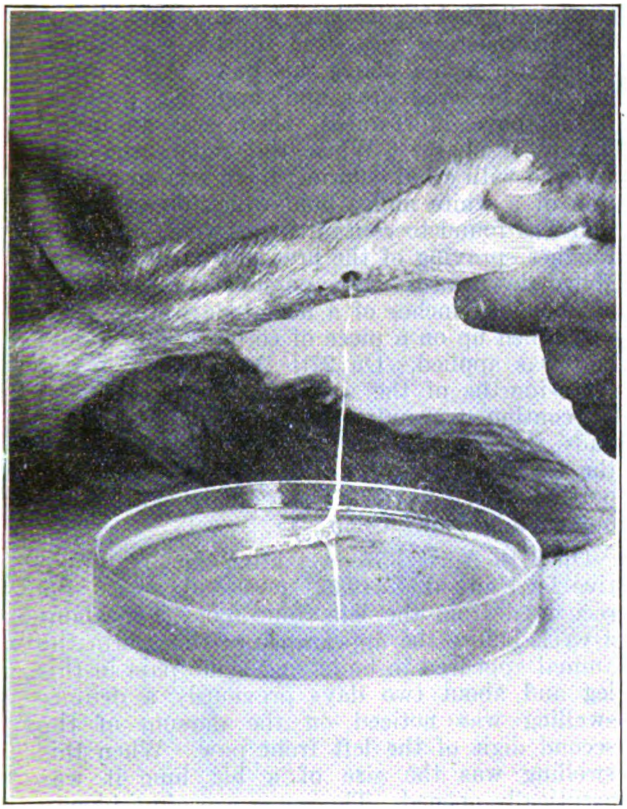


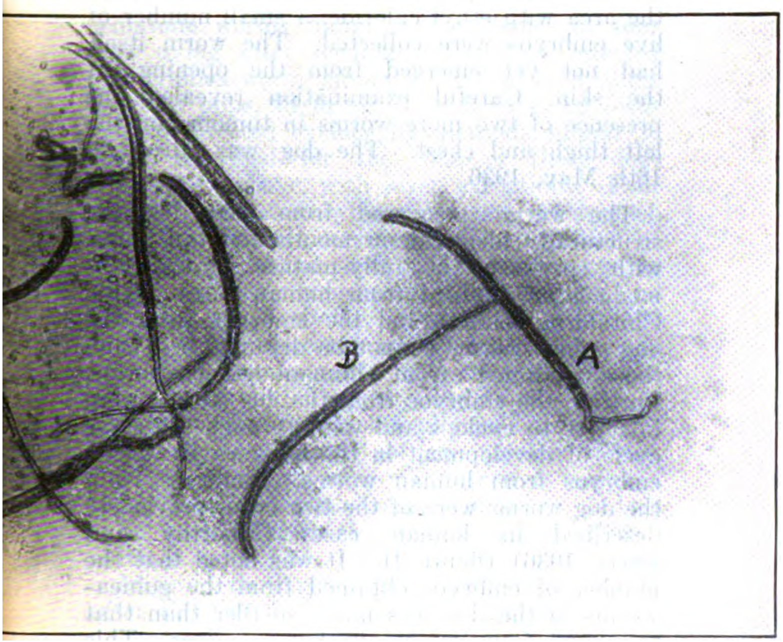
Fig. 1.—Left hind leg of living infected animal showing a guinea-worm appearing from an opening in the left hind foot.

dog has had a maximum of 9.0 per cent eosinophilia.

On 20th April, 1936, which was 350 days after the first and 331 days after the last feed of infected cyclops in 1935, the dog became noticeably restless, refused food and was found to have a rectal temperature of 104°F. It was continually licking its hind left foot and during the afternoon a pea-sized blister was found about two inches above this paw. After opening the blistered area and applying pressure from above downwards, there was an initial bloody discharge. When the same area was sprayed with ethyl chloride, there was an exudation of a white milky fluid which on examination was found to contain living worm embryos. Further spraying of the area and pressure from above downwards made possible the extraction of about six inches of a nematode worm. This was rolled up on a piece of cotton before a cold pad was applied. On 27th April, when nearly three-fourths of the worm had been extracted by continuous winding and application of cold pads, the animal pulled off all the dressings on the leg and with them tore loose the extracted portion of the worm. The wound healed without complications (figure 1).

On 27th April, 357 days after the first infective feed in May 1935, a second worm was recovered from the left front foot. For about a week before the appearance of this worm the animal appeared to be having acute pain in this leg and about two days previously a definite swelling was noticed on the dorsum of the second digit of the left front paw. When this swelling was the size of a big lime it was aseptically opened. There was a profuse bloody discharge and, on applying pressure at the sides, about ten inches of the worm emerged. No embryos were recovered upon spraying with ethyl chloride and the mouth portion of the worm was found to have undergone decomposition. With the application of cold bandages for three days, the remainder of the worm was recovered uninjured.

The presence of a third worm being felt as an oblong flattened tumour about four inches in length and ⅛ inch in breadth (feeling to the touch like a skein of thick twisted cord), on the inner surface of the proximal third of the right thigh, an incision about one inch in length was made along the length of the swelling on 29th



g. 2.—Embryos from the dog guinea-worm. A and B are two types of embryos found in human guinea-worms. × 80.

April, 1936, and the worm was partially extracted. After drawing out about three-fourths of the worm, the tail was found imbedded in the deeper tissues of the thigh in such a position that an extensive operation would have been necessary to release it, so the extracted portion was rolled on a piece of cotton and a cold bandage applied. On 1st May the dog again pulled off all the dressings and tore loose the extracted portion of the worm. The wound later healed completely without complications.

Also, on the 29th April, a small blister of the size of a bean was seen on the left side of the scrotum. On opening the blister and spraying the area with ethyl chloride, a small number of live embryos were collected. The worm itself had not yet emerged from the opening of the skin. Careful examination revealed the presence of two more worms in tumours on the left thigh and chest. The dog was alive on 16th May, 1936.

The worms recovered from this dog are structurally identical, in mouth and tail parts, with specimens of fully-mature *Dracunculus medinensis* obtained from human cases in the Chitaldrug district and the embryos from the dog guinea-worms cannot be distinguished from those obtained from human guinea-worms. Further, the embryos from the dog worms were infective to cyclops and went through the same cycle of development in the body cavity as do embryos from human worms. Embryos from the dog worms were of the two types previously described in human cases (Moorthy and Sweet, 1936) (figure 2). It was noted that the number of embryos obtained from the guinea-worms in the dog was much smaller than that recovered from worms in human cases. This may have been due to the development of these worms in an unusual host.

In view of the history of this dog and the identity between the worms and embryos recovered with those from human cases, the conclusion that this is a case of *Dracunculus medinensis* infection of the dog is justified. A control dog kept under the same conditions as the animal reported on has shown no signs of such infection, so the cause of the infection in this dog may be taken to be the infecting feeds of cyclops containing fully-developed guinea-worm embryos.

Worms recovered in post-mortem examinations of dogs

The second part of this note concerns certain nematode worms found in the tissues of four dogs dying after feedings of cyclops infected with guinea-worm embryos. Since 1934 three series of pups, 28 in all, have been given feedings of infected cyclops by methods similar to those described for the one of these dogs reported on above, with seven exceptions. Four got their infected cyclops through a stomach tube, one received a subcutaneous injection of about one thousand fresh guinea-worm embryos obtained directly from a worm in a patient, and the sixth got a similar injection of about 150 live embryos dissected out of infected cyclops after full development; the seventh, no. 28, received, by squirting into the throat from a pipette, a total of 88 naturally-infected cyclops found in the step-well of an infected village. Two extra puppies were maintained as controls, being kept under the same conditions and in close association with some of the infected animals.

At intervals varying from one to four months after the first infective feeding, all the experimental animals became ill with digestive disturbances and pustular eruptions of the skin. Some recovered with the omnadin and milk injections but 24 died in from two to five months after infection, usually with nervous symptoms or in convulsions. Since one of the control dogs died with this train of symptoms, further experiments are required to prove that they were related to the previous infective feedings.

Post-mortem examinations were done on all these dogs but nothing of interest to this experiment was found until the last four autopsies. In the connective tissues of these four dogs, two types of nematode worms were found. It is now felt that such worms were possibly present in some of the other dogs but were missed on account of lack of knowledge as to just where and how to search.

These last four examinations were done on dogs numbered 19, 20, 21 and 28. Dog no. 19 got a total of 90 infected cyclops and 60 fully developed larvæ squirted into its throat from a pipette on the 5th, 10th and 21st of October 1935; it died on 3rd February, 1936, just 105 days after its last infective feeding. Dog no. 20 got by the same methods a total of 90 infected cyclops and 50 released larvæ, on 10th, 11th and 21st October and on 14th November, 1935; it died on 8th March, 1936, which was 115 days after its last feeding. Dog no. 21 was given 81 infected cyclops and 51 released larvæ on 10th, 18th and 21st October, 1935, and it died 144 days after the last date given. Dog no. 28 received its 88 naturally-infected cyclops on 19th, 22nd and 23rd January, 1936, and died 67 days later on 30th March.

Estimations of the eosinophile percentages in the blood of all dogs were made every two weeks. The average percentage of eosinophiles of the four dogs autopsied last was 6.1 before the infective feedings began and 24.0 at the last examination before death, the maximum final

TABLE I

Nematode worms found post-mortem in four dogs previously given feedings of guinea-worm larvæ

	Dog no. 19	Dog no. 20	Dog no. 21	Dog no. 28
Number of female worms ..	1	74	18	44
Number of male worms ..	5	17	7	7
Where found	Retro-œsophageal; beneath right scapula.	Right orbit; meninges; retro-œsophageal; thorax; abdominal wall, peritoneal cavity; extremities.	Scalp; retro-œsophageal; thoracic wall; abdominal wall; extremities.	Retro-œsophageal; thoracic wall; extremities.
Total number of infected cyclops and fully-developed embryos fed to dog.	150	140	132	88
Number of days between last infective feed and death.	105	115	144	67
Age at time of infection ..	1½ months	3 months	2½ months	2 months

count being 34.0 per cent in dog no. 20. The smallest increase was in dog no. 28, which lived only 67 days after infection, and this was from 4.0 to 12.0 per cent. At no time has the remaining control dog shown an eosinophilia of over 9.0 per cent, its initial count on 18th February, 1935, being 1.4 and the last count on 18th April, 1936, being 4.2 per cent.

From the first three of these dogs, 122 nematode worms of special interest were recovered. These could be classed as of two types, a long worm and a short worm, of quite different structure. Possibly due to the shorter period between infection and death, the 51 worms found in the tissues of dog no. 28 were all short; they were, however, of the same two classes as regards structure. Table I gives details for each dog of numbers and type of worm, regions in which they were found, and a summary of the infection data, with the number of days elapsing between infection and death.

The longer nematode worms are thin and thread-like and varied, before preservation, from 7.0 to 49.0 cm. in length. A dark-coloured band runs from the anterior third practically to the end of the tail. The anterior end is dome-shaped and the cuticle is noticeably thickened around an oval mouth opening. On either side of the mouth two prominent papillæ are situated. Posterior and lateral to these, two additional rounded papillæ can be distinguished, about half the size of the more central pair (figures 3 and 4). Another small papilla can be seen in the cervical region. The tail is bluntly pointed and curved ventrally (figure 5). Situated 0.6 mm. above the posterior extremity (total length of worm 15 cm.) is the anus.

The shorter worms are also thread-like with a maximum length, before preservation, of 2.4 cm. and a breadth of 0.7 mm. In the case of these worms the dark band starts at about the middle of the body and runs to about 0.2 mm. above the tip of the tail. The two central papillæ of the mouth are clearly seen but the lateral ones are not as prominent as in the female (figure 6). The papillæ in the cervical region are present. The tail is spirally curved ventrally and has two openings with thick labiæ, the anterior one being, on the average, 0.2 mm. above the tip of the tail and the posterior just beyond it. Between these openings and the tail tip are two globular papillæ, apparently not pedunculated. The tail itself is bluntly pointed and ends in a sharply curved

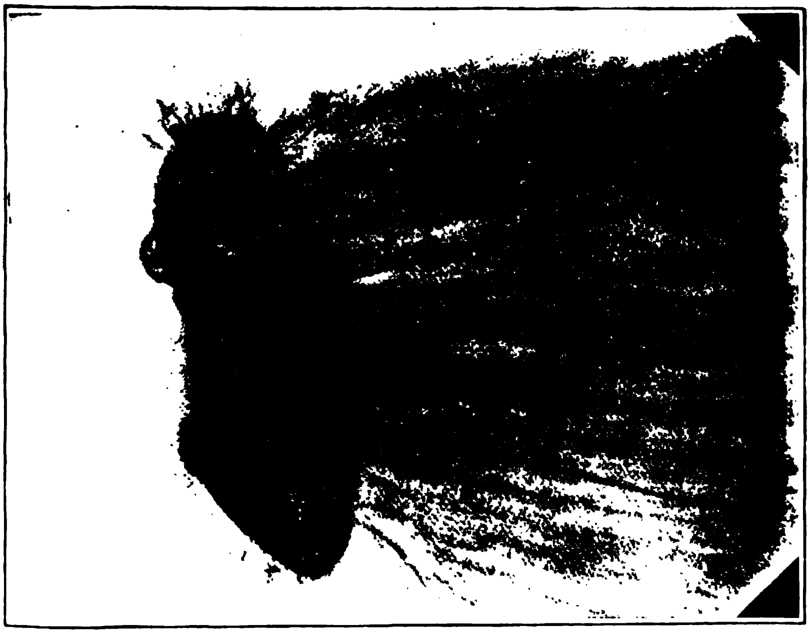


Fig. 3.—Mouth end of female worm found post mortem in dog no. 20. × 180.

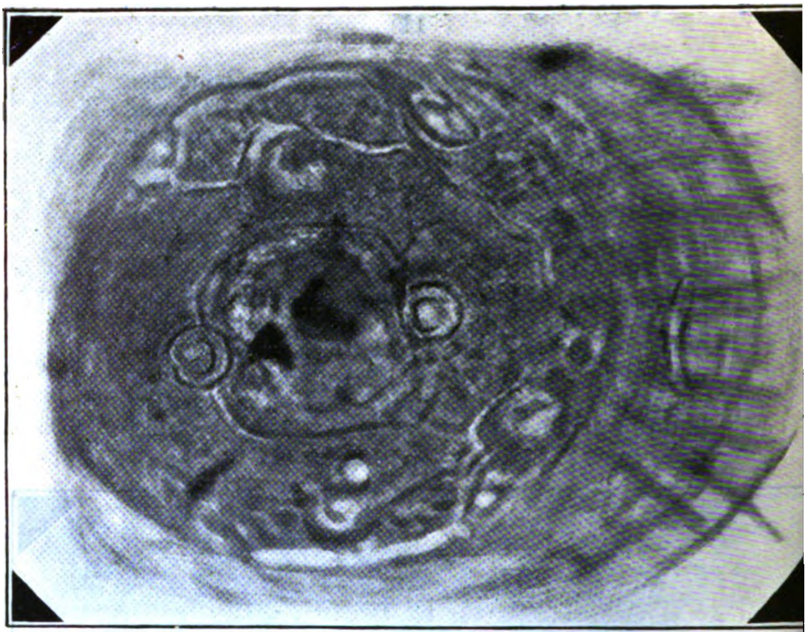


Fig. 4.—Transverse section of mouth end of female worm found post mortem
dog no. 20. × 210.

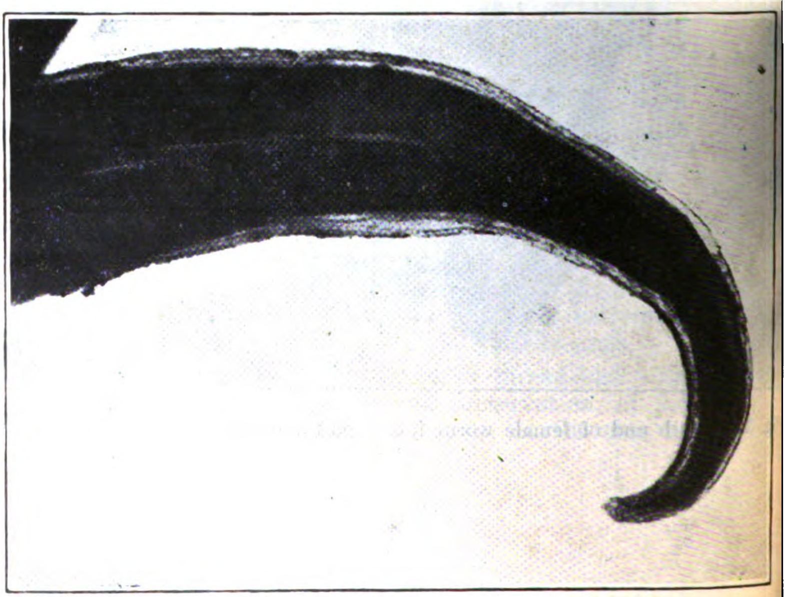


Fig. 5.—Tail end of female worm found post mortem in dog no. 20. × 160.

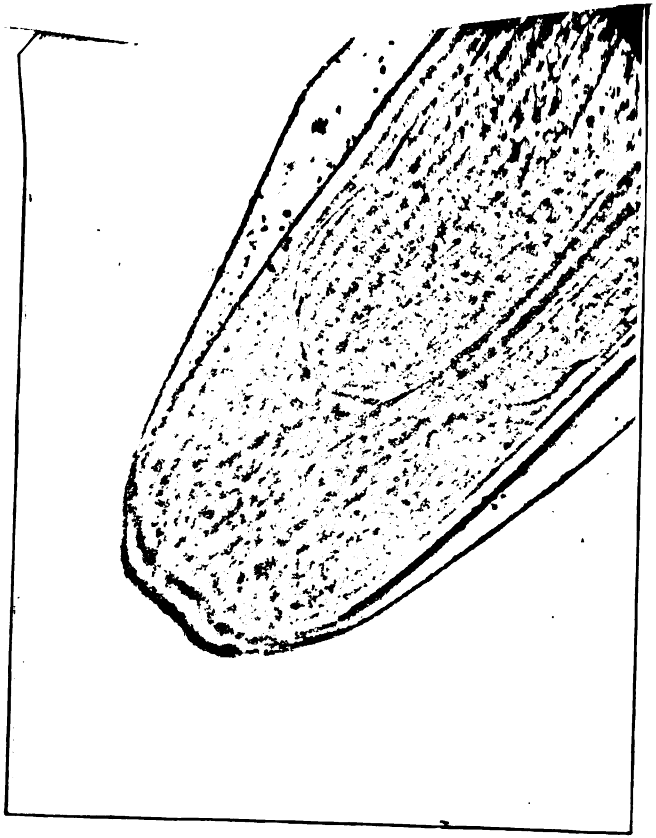


Fig. 6.—Mouth end of male worm found post mortem in dog no. 20. × 160.

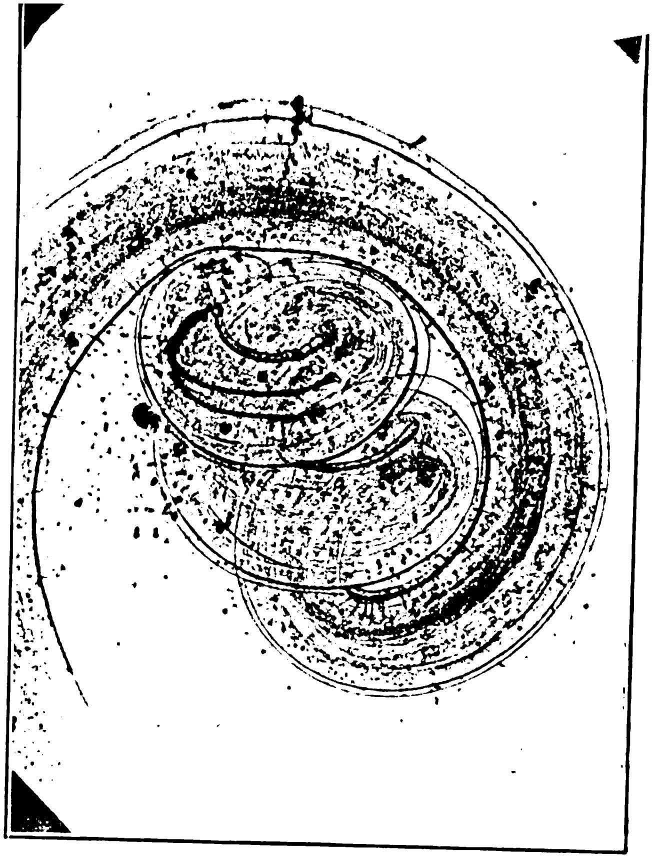


Fig. 7.—Tail of male worm found post mortem in dog no. 20. × 160.

hook. Two brownish spicules, of about equal length, start in funnel-shaped anterior ends and extrude, in sharp points, from the upper of the two openings mentioned. The left ventral spicule averages, in three specimens, 0.55 mm. in length and the right dorsal 0.53 mm. (figure 7).

In the case of dog no. 28, which lived only 67 days after its infective feeding, worms of the same two types were found and in similar situations. These worms, however, are much shorter, varying from 1.5 to 2.4 cm. in length after preservation. In the females, only the two central papillæ can be found at the mouth

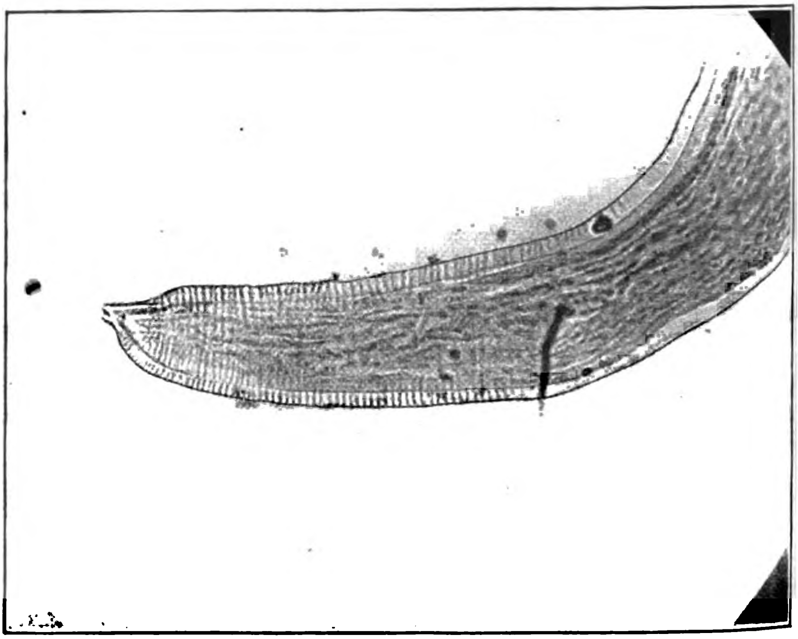


Fig. 8.—Tail of young form of female worm found post mortem in dog no. 28. × 160.

end and the tail shows the tri-partite ending so characteristic of the guinea-worm embryo after it has undergone its full development in cyclops (figure 8). The other type of worm in this dog is the same structurally as the male worm of the other dogs, with the characteristic mouth end, spirally curled tail, and two equal spicules.

In view of the history given of these four dogs, and of the finding of adult guinea-worms in another dog, it is suggested that the longer of these two types of worms are specimens of immature female *Dracunculus medinensis* and that the shorter is the more mature male. Full confirmation of this suggestion will have to await more adequate facilities than are at present available for a detailed study of the external and internal structures of these worms. It may be of interest to point out that, if the suggestion that these are male and female guinea-worms is correct, the report confirms Leiper's (1907) finding in a monkey and his view that fertilization of the female guinea-worm takes place in the tissues of the final host and not in the gastro-intestinal tract.

Special appreciation must be expressed for the assistance of Mr. L. N. Rao of the Central College, Bangalore, in taking the microphotographs.

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OBSERVATIONS ON THE DEVELOPMENT OF *DRACUNCULUS MEDINENSIS* LARVAE IN CYCLOPS[1]

BY

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(Received for publication January 15th, 1938)

Although Fedtschenko indicated as early as 1871, that the larva of *Dracunculus medinensis* underwent definite developmental changes in cyclops, no detailed morphological study of the different developmental stages of the larva in the crustacean intermediate host or in the final vertebrate host appears to have been made. The available information on the metamorphosis of the *Dracunculus* larva in cyclops is very scattered in the literature and the details given by one worker very often do not agree with those of another. Fedtschenko (1871), who continued his observations on the larva of *D. medinensis* in the infected cyclops up to the fourth week after infection, states that the metamorphosis was completed on the twelfth day. Manson (1893), working with English cyclops in London, found that ecdysis was postponed until the sixth week. Leiper (1907), working in Africa, found that the "striated cuticle of the embryo was cast generally on the eighth day" and that the larva lost, 2 days later, "a very delicate enveloping pellicle" and that its further development, such as increase in size and differentiation of internal structures, took place up to "about the fifth week when it apparently became mature." Fairley and Liston (1924), working in India, observed that the metamorphosis of the larvae was completed by about the

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fifteenth day after infection of cyclops and also found that such larvae were infective to human volunteers. Issajev (1934), working in Russia, found that the larva was infective to experimental dogs after it had molted twice in cyclops; i.e., usually about 13 days after the infection. Manson-Bahr (1936) states that the larvae "cast their skins two or three times, get rid of their long swimming tail, acquire a cylindrical shape and ultimately along with increased size develop a tripartite arrangement of the extreme posterior end as in *F. bancrofti* and *Loa loa.*" Craig and Faust (1937) state that the larva undergoes metamorphosis in the body cavity of cyclops "with one ecdysis (possibly two) and that sometime after the tenth or twelfth day this process is completed" when the larva becomes infective to the vertebrate host.

In view of these rather indefinite and sometimes conflicting reports on the development of the *Dracunculus* larva in cyclops, it seemed desirable to make a detailed study of its metamorphosis and to follow its further development in a suitable, experimental, vertebrate host. In previous publications (Moorthy and Sweet, 1936 a and 1937), the results were given of the experimental infection of four series of dogs, 32 in all, with *D. medinensis.* In another publication (Moorthy, 1937 b), the description was given of some of the developmental stages of *D. medinensis,* both males and females, obtained from the experimental dogs after 67 to 457 days following infection. In this paper it is proposed to give a brief description of the first stage larva of *D. medinensis* and of its further developmental stages in cyclops.

In a previous preliminary report (Moorthy and Sweet, 1936 d), a brief description was given of two types of the larva (type A and type B) that were obtained from the same adult *D. medinensis* and it was then suggested that these two types probably represented the sexes of the larva. It has become possible since then to make a more careful structural study of these two types of larvae, the results of which are also given in this paper.

MATERIALS AND METHODS

Dracunculus medinensis larvae. Fresh larvae were obtained from early cases of dracontiasis (blister stage; plate V; fig. 18) in human beings, before any septic infection of the wound had occurred, from the village of Medikerpure in the Chitaldrug District, Mysore, India. This village was preferred as the larvae and cyclops infected under natural conditions, obtained from it, had been used in a previous experiment for the infection of dogs (Moorthy and Sweet, 1936 a).

The larvae were usually extracted by opening the blister aseptically and spraying the area with ethyl chloride. In some cases the entire worm was removed by surgical means and the larvae were obtained from it by drawing out the uterus. As a rule only fresh, very actively motile larvae, extracted not more than 1 hour before the experiment, were used for the infection of the cyclops.

Cyclops. Mesocyclops leuckarti and *Mesocyclops hyalinus* were the most common and the most universally distributed species in the Chitaldrug District. Since these were the only two species that were found infected with *Dracunculus* larvae in nature (Moorthy and Sweet, 1936 c), they were used in all the laboratory infections also, being obtained from a step-well in an uninfected village.

Infection of cyclops in the laboratory. Several thousands of cyclops (*M. leuckarti* and *M. hyalinus*) were isolated in about 10 to 15 liters of fresh step-well water strained through fine muslin or a cotton plug and several thousand fresh *Dracunculus* larvae, obtained not more than about 1 hour before the experiment, were added. A few specimens of cyclops, selected at random, were examined at the end of every half hour and, when the majority of them were infected, usually at the end of about 12 hours, the infected specimens were separated from the uninfected ones. About 12 hours later, the infected cyclops were once again examined and those with only one or two larvae were separated from the more heavily infected ones. Since, under natural conditions, the cyclops were never found to be infected with more than one *Dracunculus* larva (Moorthy and Sweet, 1936 c), the specimens with one or two larvae were the only ones that were used for the subsequent developmental study of the larvae. About five to ten specimens of cyclops selected at random from the culture were examined every 24 hours for the first 3 weeks and every week thereafter. When the larvae were observed to be undergoing any definite developmental change, like the first or second molt, large numbers of cyclops (about 50 to 100) were dissected and the larvae showing these definite developmental changes were fixed, stained, and mounted by the author's method (Moorthy, 1937 a) and were subsequently used for structural study.

General observations on the infection of cyclops with the Dracunculus medinensis *larvae in the laboratory*

1. The cyclops became infected always by swallowing the larvae which, in about 1 to 6 hours, reached the body cavity where they underwent the developmental changes described later.

2. Immature forms of both the species of cyclops (*M. leuckarti* and *M. hyalinus*) became infected more easily than the adults. Infection appeared to be relatively more common and heavier in *M. leuckarti* than in *M. hyalinus* and in the females of both species than in the males.

3. The longest period for which an infected cyclops (*M. leuckarti* infected with two larvae) could be kept alive in the laboratory was 107 days (April to August); the majority of the infected cyclops lived for only 20 to 25 days after infection; the mortality rate gradually increased to around 80 per cent by about the fortieth day after infection.

4. Under natural conditions, so far, only a single larva has been found in an infected cyclops. Under laboratory conditions as many as fifteen to twenty larvae have been found. As a rule these heavily infected cyclops were sluggish and had a tendency to remain at the bottom of the containers; they did not usually live in the laboratory for more than 25 to 30 days.

5. Contrary to expectations, it was observed that the greater the volume of water in which the infected cyclops were isolated, the less were their chances of surviving for a longer period. In one experiment it was observed that out of 600 infected cyclops isolated in a shallow dish containing about half a liter of water, ten were alive on the seventieth day of the infection. Out of the same number of infected cyclops isolated in a big jar (height about 1.5 feet) containing about 12 liters of water, all were dead on the thirty-first day. This is probably because the infected cyclops always have a tendency to remain at the bottom of the container and consequently possibly suffer to a greater extent from insufficient aeration in tall jars containing large volumes of water, than in shallow ones. From this observation it seems possible that, since the water level in the wells is usually very low during summer, the chances of the infected cyclops surviving for a longer period appear to be greater then. This is probably one other factor responsible for the transmission season of *D. medinensis* being during the summer.

6. In cyclops infected with less than five *Dracunculus* larvae, all completed the development at about the same time after infection. In cyclops that were infected with larger numbers of larvae, it has been generally observed that some of the larvae undergo their development only as far as the first or second ecdysis, however long they remain in the cyclops; in the case of a few that succeeded in undergoing complete development, the time taken for development was

not the same for all and was in addition found to be invariably prolonged by about 7 to 12 days as compared with that in cyclops infected with one or two larvae.

7. In cyclops infected with *Dracunculus* larvae obtained from cases in which septic infection of the wound had taken place, the development of most of the larvae proceeded only as far as the first or second ecdysis. For the few which did succeed in completing the full development the time was prolonged by about 10 days. In addition it was observed that when such infected cyclops were treated with dilute HCl (0.2 per cent) or fresh fish bile, the larvae, instead of being stimulated to activity, died in the body cavity after making a few feeble movements.

8. Cyclops were infected first with *Camallanus sweeti* larvae and when these larvae had undergone full development (i.e., about 10 to 12 days after infection) they were superinfected with *Dracunculus* larvae (Moorthy, 1937 c). The guinea worm larvae were observed to undergo their normal developmental changes in such cyclops but the time taken was found to be prolonged by about 5 to 8 days as compared to those in the control experiment in which cyclops were infected only with *Dracunculus* larvae.

9. In a series of cyclops infection experiments it was uniformly observed that as many as 30 to 40 days after infection; i.e., at a period sufficient for any immature infected cyclops to have grown to a mature adult, immature infected cyclops continued to persist in the jars. This observation suggests that the infection with *Dracunculus* larvae had retarded the growth to maturity of at least some of these cyclops. The only other possibility is that immature cyclops, accidentally introduced while changing water, might have become infected with the third stage larva of *D. medinensis,* either by feeding on other infected cyclops containing third stage larvae or on the third stage larvae released from dead and degenerated cyclops. So far all attempts to infect immature cyclops with the third stage larvae obtained from other infected cyclops have been unsuccessful. Hence it appears to be probable that when immature cyclops become infected with the *Dracunculus* larva, further development to maturity is arrested in at least a few of them. It has also been observed that, as a rule, the infected cyclops do not form fresh brood capsules, suggesting that the infection also affects in some way (probably by pressure atrophy of the ovaries), the normal functioning of the genital system.

10. About 200 specimens of cyclops, 100 each of *M. leuckarti* and *M. hyalinus,* were infected with two or three *D. medinensis* larvae.

After the larvae had undergone their full development; i.e., about 2 to 3 weeks after the infection, these cyclops were superinfected with fresh *Dracunculus* larvae. It was observed that 60 to 70 per cent of them died within 24 hours after superinfection. The relative resistance to superinfection and the mortality after superinfection was higher in *M. hyalinus* than in *M. leuckarti.* Also, the development of the superinfected *Dracunculus* larvae was greatly retarded and in general it resembled that observed in cyclops infected with more than five *Dracunculus* larvae.

11. Small numbers of fresh *Dracunculus* larvae were kept at room temperature for 1 hour in each of the following solutions: (1) 1 to 1,000 acriflavine; (2) 1 to 500 methylene blue (watery solution); (3) 0.2 per cent HCl, and (4) undiluted, fresh, fish bile from *Barbus puckelli* and *Barbus ticto.* In a previous preliminary experiment it had been observed that the larvae remained actively moving in all these solutions for over 3 hours. Cyclops were then infected with the larvae isolated in these different solutions and the development of the larvae followed. Specimens of cyclops infected with fresh larvae that had been isolated in distilled water for the same period were used as a control. It was observed that the smallest percentage of cyclops became infected with the larvae treated with 0.2 per cent HCl or fresh fish bile and the largest percentage with those treated with 1 to 1,000 acriflavine or 1 to 500 methylene blue. The majority of the larvae that had been treated with 0.2 per cent HCl or fish bile did not undergo development beyond the first ecdysis. In the case of the larvae treated with acriflavine or methylene blue, the complete development took place in a few instances, but the time taken for it was prolonged by 4 to 6 days as compared to those in the control experiment.

12. Fresh water fish (*B. puckelli, B. ticto,* and adult and very young *Gambusia*) were fed with large numbers of fresh *Dracunculus* larvae. After the feeding each species of fish was segregated in distilled water and their feces separately collected and examined. The samples of feces containing the *Dracunculus* larvae were kept separately in fresh, strained, step-well water and cyclops were infected with them using, for the control, cyclops infected with fresh larvae. It was observed that the greatest number of live, actively motile, *Dracunculus* larvae were passed in the feces of young *Gambusia* and the least in *B. puckelli,* in which case the majority of the larvae were digested by the fish and only the undigested cuticles of the larvae were found in its feces. Also, the infection of cyclops was greatest

with the sample of larvae obtained from the feces of young *Gambusia* and least with that from the feces of *B. puckelli.* It was only with larvae obtained from the feces of young *Gambusia* that complete development in cyclops took place at approximately the same time as in the control experiment. Only a few of the live larvae in the feces of *B. puckelli* underwent complete development in cyclops, and the time taken for it was invariably prolonged by about 8 to 10 days as compared to those in the control experiment. The results were very varying with the larvae passed in the feces of *B. ticto* and adult *Gambusia;* in some, complete development took place at approximately the same time as those in the control experiment and in others the development was retarded or arrested completely.

Description of the early developmental stages of D. medinensis

First stage larva. Small numbers of fresh *Dracunculus* larvae from the same sample that was used for infecting the cyclops to study the developmental changes, were fixed, stained in bulk, and mounted by the author's method (Moorthy, 1937 a). While fixing the larvae with the solution (mercuric perchloride 0.52 gms., sodium chloride 1.04 gms., and distilled water 100 cc.), a peculiar effect on the larvae was observed. The majority of them were observed to vomit out gradually their entire esophagus and intestines (Pl. V; fig. 19) before they finally died in the course of 15 to 20 minutes. When fixed by this method, the posterior half of the body was found to be more shrivelled and shrunken than the anterior portion. To overcome this difficulty a boiling solution of the fixative was used since this killed the larvae almost instantaneously without any shrivelling of the posterior half of the body. In this solution the larvae died fully extended, with the esophagus and intestine in situ and in a condition quite suitable for structural study. The method of killing the larvae slowly by the use of cold fixative was, however, found admirably suited for securing a large number of the esophago-intestinal tracts of the larvae, freed completely from their body, for structural study. This fixative has been, so far, observed to have this peculiar effect only on the first stage *Dracunculus* larvae and not on any of the later stages. It is possible that this solution, when used in different strengths, will have the same effect on these later stages of the larvae and possibly also on the adults. It would be of interest to see, especially from the point of view of the treatment of dracontiasis, whether this solution, when injected into the body of the adult females in suit-

TABLE 1

Measurements of the larvae of Dracunculus medinensis

No.	Stage of development of the larvae	Total number examined	Total number used for measurements	Body measurements, averages in mm.									
				Total body length	Greatest body width	Nerve ring (from anterior extremity)	Esophagus length	Genital primordium (from anterior extremity)	Anus (from anterior extremity)	Tail length	Distance of knob from the anus	Total length of the dorsal filiform appendage	Distance of the filiform appendage from the anus
	Normal larvae												
1	Early first stage larva (from mature *D. medinensis*)	Large number	10	0.608	0.018	0.071	0.140	0.301	0.380	0.219	—	—	—
2	Late first stage larva undergoing the first molt (from experimentally infected cyclops)	Large number	10	0.396	0.016	0.056	0.122	0.257	0.328	0.070	—	—	—
3	Second stage larva undergoing the second molt (from experimentally infected cyclops)	Large number	10	0.391	0.020	0.060	0.172	0.274	0.350	0.044	—	—	—
4	Third stage larva (from experimentally infected cyclops), both short and long forms	Large number	40	0.451 ±0.009	0.018 ±0.0002	0.060 ±0.001	0.212 ±0.006	0.304 ±0.007	0.404 ±0.008	0.045 ±0.001	—	—	—
	Abnormal larvae												
1	Early first stage larva (from mature *D. medinensis*)	Large number	10	0.459	0.023	0.070	0.114	0.301	0.370	0.083	0.035	0.109	0.056
2	Late first stage larva undergoing first molt (from experimentally infected cyclops)	3	3	0.453	0.016	0.069	0.146	0.305	0.371	0.084	—	0.106	0.070
3	Third stage larva (from experimentally infected cyclops)	1	1	0.410	0.015	0.065	0.208	0.302	0.380	0.028	0.02	—	—

able dilutions, would induce them to throw out their entire uteri with the larvae in them.

In about fifty cases of dracontiasis that were examined in the early blister stage, in different infected villages in the Chitaldrug District, two types of first stage larvae; i.e., type A, a rare form with a very short tail containing a long filiform appendage, and type B, the common normal form with a very long tail, were obtained from the same adult worm. The number of each type present in about 100 permanent slide preparations was counted and the ratio of type A to type B was found to be about 1 to 900. In table 1 the different measurements of the larvae are given. In table 2 the de Man's proportional measurements are given for $\alpha =$ total body length/body width, $\beta =$ total body length/esophagus length, and $\gamma =$ total body length/tail length, and the location of the genital primordium is given as a percentage of the total body length from the anterior extremity. The description given below refers to the normal first stage *Dracunculus* larvae, designated as type B in a previous publication (Moorthy and Sweet, 1936 d) and to their different developmental stages in cyclops. The description of the abnormal larvae, designed as type A, is given in the later section of this paper. The description and the measurements given are of the larvae fixed, stained, and mounted by the author's method (Moorthy, 1937 a).

Description of the early first stage larva (Pl. 1; figs. 1 to 4). Body length 0.581 to 0.635 mm.; greatest width of body, slightly anterior to the esophago-intestinal valve, 0.01 to 0.024 mm.; $\alpha = 27$ to 35.8, $\beta = 3.2$ to 4.5, $\gamma = 2.5$ to 3.2; genital primordium 45.4 to 57.2 per cent; oral opening wide, conspicuous, and surrounded by an internal circle of six papillae (interno-laterals small and separate, interno-ventrals and interno-dorsals, very conspicuous and always distinctly separated) and an external circle of four double papillae. Amphids large, pore-like, conspicuous, and posterior to interno-lateral papillae. Triangular denticle situated at about the middle of interno-dorsal pair of papillae (fig. 3). Esophagus 0.13 to 0.15 mm. long; nuclei very conspicuous and situated in posterior third; wall very thin and lumen considerably dilated and appearing to contain a hyaline substance which takes deep eosin color. Nerve ring 0.061 mm. to 0.08 mm. from anterior extremity. Excretory pore slightly posterior to nerve ring; excretory cell nucleus conspicuous and situated slightly anterior to esophago-intestinal valve. Intestines consisting of twelve to fifteen cells which contain transparent globules; wall very thin; lumen very much dilated and containing in its anterior three-fourths a hyaline substance taking deep eosin color. Genital primordium, 0.27 to 0.36 mm. from anterior extremity; eight to ten times as long as broad and composed of four cells, arranged as shown in figure 2; third cell from anterior end being largest and most conspicuous. Rectum 0.013 to 0.03 mm. long; thin, tubular and nearly four times as long as broad. Anus 0.36 to 0.4 mm. from anterior extremity. Phasmids slightly posterior to anus, conspicuous, large, and pouch-like (figs. 2 and 4). Tail 0.19 to 0.26 mm. long; filiform, thin, long, and gradually tapers to a sharply pointed tip.

TABLE 2

de Man's proportional measurements of the larvae of Dracunculus medinensis *

No.	Stage of development of the larvae	de Man's proportional measurements (averages)			
		$\alpha = \frac{\text{Total body length}}{\text{body width}}$	$\beta = \frac{\text{Total body length}}{\text{esophagus length}}$	$\gamma = \frac{\text{Total body length}}{\text{tail length}}$	Genital primordium (per cent of body length from the anterior extremity)
	Normal larvae				
1	Early first stage larva (from mature *D. medinensis*)	30.8	4.1	2.7	50.5
2	Late first stage larva undergoing the first molt (from experimentally infected cyclops)	25.5	3.2	5.8	63.8
3	Second stage larva undergoing the second molt (from experimentally infected cyclops)	20.1	2.3	9.5	69.5
4	Third stage larva (from experimentally infected cyclops), both short and long forms	25.4 ± 0.56	2.1 ± 0.04	10.3 ± 0.17	67.6 ± 0.55
	Abnormal larvae				
1	Early first stage larva (from mature *D. medinensis*)	23.4	3.4	5.2	64.5
2	Late first stage larva undergoing the first molt (from experimentally infected cyclops)	28.3	3.1	5.5	66.7
3	Third stage larva (from experimentally infected cyclops)	27.4	1.9	14.7	73.4

* Total number of specimens examined and used for measurements were the same as in table 1.

Very early first stage larva. From some of the *D. medinensis* extracted from experimental animals (Moorthy and Sweet, 1936 a), it was possible to obtain early developing forms (0.1 to 0.2 mm. in length) of the first stage larvae. It was observed that at this stage also both the normal and the abnormal types of larvae were present in about the same proportion as in the later fully developed stage. The only structures that could be distinctly made out at this stage were the large, pouch-like phasmids, situated slightly posterior to anus.

First stage larvae in cyclops undergoing the first molt (Pl. 3; figs. 10 and 11). Large numbers of larvae just completing the first molt were obtained from experimentally infected cyclops. Average measurements of ten specimens are given in tables 1 and 2. The larvae appear to undergo the first molt between the fifth and seventh day after infection in hot weather (90 to 102° F) and between the eighth and twelfth day in cooler weather (55 to 70° F). While still undergoing the first molt and before it has cast off the exuviae, the larva starts undergoing the second molt also (fig. 11) and when the larva is just completing the first molt, the exuviae of the second molt becomes evident throughout its length and more particularly at the tip of the tail. While measuring this stage larva, the measurements of the first exuviae are excluded but those of the second are included.

Description. Body length 0.310 to 0.439 mm.; greatest width slightly posterior to nerve ring 0.013 to 0.019 mm.; $\alpha = 16.3$ to 32.0; $\beta = 2.6$ to 4.3; $\gamma = 4.4$ to 7.2; genital primordium 53.1 to 73.1 per cent of body length from anterior extremity. In anterior portion of exuviae, molted portion of old stoma, cephalic papillae, and esophagus distinct (fig. 10). Dorsal denticle not present. Transverse cuticular striations, fine and not so deep or distinct as in early first stage larva. Nerve ring 0.043 to 0.064 mm. from anterior extremity. Excretory pore slightly posterior to nerve ring. Esophagus 0.095 to 0.148 mm. long; differing from that of early first stage larva in having a very thick wall and narrow lumen. Intestines consisting of 25 to 30 cells which contain transparent globules; wall thick and lumen narrow. Genital primordium 0.2 to 0.29 mm. from anterior extremity; consisting of four cells and being about half as long and of about same width as that of early first stage larvae. Rectum long, tubular, and nearly five times as long as broad. Anus 0.26 to 0.37 mm. from anterior extremity. Phasmids slightly posterior to anus (fig. 11). Tail 0.046 to 0.094 mm. long; at tip four characteristic mucrones just being formed and covered by cone-shaped thin exuviae of second molt (fig. 11). The posterior portion of exuviae was filled with partly hyaline and partly granular material, probably the products of metabolism of the larvae, excreted while undergoing the first molt, and collected in the exuviae.

Second stage larva undergoing the second molt (Pl. 3; figs. 12 and 13). The larva appears to undergo the second molt between the eighth and twelfth day after infection during hot weather (90 to 102° F) and between the thirteenth and sixteenth day in cooler weather (55 to 70° F). A large number of specimens was studied and the average measurements (excluding that of the exuviae) of ten of these selected at random are given in tables 1 and 2.

Description. Body length 0.28 to 0.48 mm.; greatest width, near esophago-intestinal valve, 0.018 to 0.026 mm.; $\alpha = 11.0$ to 24.0; $\beta = 2.0$ to 2.8; $\gamma = 7.0$ to 15.6; genital primordium 64.0 to 77 per cent of body length from anterior extremity. In anterior portion of exuviae, molted portion of stoma, cephalic papillae, and esophagus distinctly made out (fig. 12). Transverse cuticular striations, very fine and indistinct. Esophagus 0.148 to 0.227 mm. long; wall thick and lumen very narrow. Nerve ring 0.05 to 0.085 mm. from anterior extremity. Excretory pore slightly posterior to nerve ring. Intestine consists of about 30 to 35 cells, containing transparent globules and a few yellowish brown granules. Genital primordium 0.2 to 0.346 mm. from anterior extremity, slightly wider and about one third as long as in early first stage; number of cells varied from 4 to 6 and all were approximately of about same size. Anus 0.263 to 0.432 mm. from anterior extremity. Phasmids slightly posterior to anus. Tail 0.016 to 0.067 mm. in length; short, stout, and bluntly pointed with four mucrones at tip (fig. 13). In posterior portion of exuviae molted portion of rectum was present; as in previous stage same granular material, possibly product of metabolism of larvae excreted while undergoing second molt, was present in exuviae (fig. 13).

Third stage larva (Pl. 4; figs. 15 and 16). Several hundred third stage larvae, dissected from cyclops 30 to 107 days after infection, were examined. In the course of about 3 weeks the *Dracunculus* larvae appear to undergo the maximum development and, from a series of experimental infections (Moorthy and Sweet, 1936 a), it has been observed that the larvae at this stage of development are infective to dogs. While taking measurements of the larvae, it was observed that some were distinctly smaller than the others, though both sizes had been obtained from cyclops infected on the same day. Average measurements of forty specimens of both short and long forms, selected at random, are given in tables 1 and 2. Structurally, both the small and the large forms were practically identical. The description and the measurements given below refer to both the sizes.

Description. Body length 0.240 to 0.608 mm.; greatest width at junction of anterior third with posterior two thirds, 0.016 to 0.023 mm.; $\alpha = 16.7$ to 34.6; $\beta = 1.8$ to 2.9; $\gamma = 8.0$ to 13.8; genital primordium 54.3 to 80.0 per cent of body length from anterior extremity. Transverse cuticular striations fine, distinct, and about 1 to 2 μ apart (fig. 15). Esophagus 0.11 to 0.364 mm. long; consists of short anterior muscular portion (about one eighth of total length of esophagus) and long, distinctly glandular, posterior portion (fig. 16); beyond slight dilatation of termination of muscular portion, line of demarcation between muscular and glandular esophagus not very distinct; esophageal wall thick and lumen narrow; dorsal and sub-ventral esophageal glands with their prominent nuclei conspicuous (fig. 16). Esophago-intestinal valve, distinct. Nerve ring 0.043 to 0.10 mm. in length, from anterior extremity. Excretory pore slightly posterior to nerve ring; excretory cell with a conspicuous nucleus situated slightly posterior to excretory pore (fig. 16). Intestine consisting of about 35 to 40 cells which are loaded with large amount of transparent globules and yellowish brown granules. Genital primordium 0.202 to 0.436 mm. from anterior extremity; in majority of specimens examined in both long and short forms genital primordium presented same appearance and consisted of six to eight cells of about same size, arranged in longitudinal row as shown in fig. 15; in a few small forms, however, it presented the appearance of a pyramid with four posterior cells arranged side by side transversely and two comparatively broader cells placed anterior to them. Rectum long, narrow, and tubular (fig. 15). Anus 0.217 to 0.557 mm. from anterior extremity. Tail length 0.02 to 0.067 mm.; short, stout, and uniformly tapers to a blunt pointed tip containing four rounded characteristic mucrones (fig. 15).

Development stage of Dracunculus larva in cyclops obtained from specimens of cyclops infected under natural conditions. A comparative study was made of the different developmental stages of *D. medinensis* larvae obtained from cyclops infected under natural conditions. Structurally these larvae were identical with the corresponding stages obtained from cyclops infected in the laboratory. The following were some of the other differences observed:

1. All the naturally infected cyclops had only one larva in each, while in those infected in the laboratory there were as many as twenty.
2. Both the naturally infected cyclops and the larvae obtained from them appeared to be more active than the experimentally infected ones.

3. The third stage larva in the naturally infected cyclops was, as a rule, stimulated to greater activity by 0.2 per cent HCl and fresh fish bile and the time taken for the larvae to escape from the cyclops was quicker (in some instances being as short as 2 to 3 minutes) than in the case of those infected under laboratory conditions.

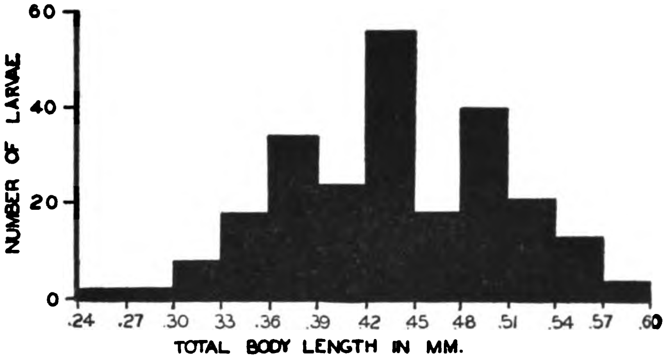
4. The third stage larvae in naturally infected cyclops appeared to contain larger amounts of brownish yellow pigmented granules in the intestinal cells than those obtained from experimentally infected cyclops.

Discussion

From the foregoing study of the metamorphosis of the larvae of *D. medinensis* in cyclops it is observed that the larvae undergo two definite molts in the body cavity. The first molt takes place between the fifth and seventh day, and the second between the eighth and twelfth day, after infection of cyclops, in hot weather (90 to 102° F). In cooler weather (55 to 70° F) the corresponding molts take place respectively between the eighth and tenth day and between the thirteenth and sixteenth day after infection. It was uniformly observed that the larva starts undergoing the second molt before it has cast off the exuviae of the first molt. Beyond a slight increase in size of the third stage larva which takes place for about a week after it casts the exuviae of the second molt, no further development was observed in any of the specimens obtained from cyclops up to 107 days after infection.

For the first 4 or 5 weeks the larvae remained actively moving in the body cavity of the cyclops but subsequently they were found tightly coiled up, making only occasional feeble movements. Both the early active and the later quiescent stages were stimulated to the same extent when treated with 0.2 per cent HCl or fresh fish bile. The larva did not show any tendency to escape from the cyclops as long as the latter was alive. It has been generally observed that the amount of pigmented granules in the intestines becomes gradually reduced if the larvae remained in the body cavity of cyclops for more than 3 weeks. From a series of experimental infections of dogs (Moorthy and Sweet, 1936 a) it was uniformly observed that the larva becomes infective to the vertebrate host 4 to 8 days after it completely sheds the exuviae of the second molt.

It was possible to follow the further development of *D. medinensis* in a series of experimentally infected dogs from 67 to 457 days after the infection. The youngest specimens obtained 67 days after infection (Moorthy, 1937 b), measured about 12 to 24 millimeters in length and were found in the deep connective tissues of the animal. As has already been reported (Moorthy, 1937 b) both the males and the females were found to be sexually mature at this stage. In addition it was noted that in females measuring 24 millimeters the vagina contained a mucoid plug, suggesting that fertilization had already taken place. The developmental stages of the parasite earlier than 67 days in the vertebrate host have not been obtained so far. It is, therefore, not yet clear as to where and when these developmental changes take place in the definitive host. It is possible that the third molt takes place while the larva is invading the tissues of the stomach or intestines and the fourth one in the deep connective tissues.



Graph 1. The frequency distribution of the lengths of 240 third stage larvae of *Dracunculus medinensis*

As pointed out in the previous section of this paper, very wide variation (0.240 to 0.608 mm.) was noticed in the length of the third stage larvae obtained from cyclops infected in the laboratory. Structurally, however, both the shortest and the longest forms were practically identical.

The different average measurements together with their probable errors of 40 third stage larvae, that had remained in the body cavity of cyclops for at least 30 days after infection, are given in tables 1 and 2. Since the widest variation was observed in the length, measurements of only the length of 200 additional larvae were taken. The frequency distribution of the lengths of all the 240 larvae is given in graph 1. This distribution appears to be trimodal, suggesting that the sample is probably heterogeneous in nature and that the observed variation in the size of the larvae has probably some specific significance. The structural identity between the shortest and the longest larvae, and the trimodal and not bimodal nature of the frequency distribution, suggest that this is probably not due to the sexual differentiation of the larvae taking place at this stage. It is, however, possible that due to some environmental condition not yet clearly understood, such as the available supply of food for the infected cyclops, the condition of the larvae before the infection of cyclops, or some other undetermined host-specific factor, the growth of some larvae becomes stunted as compared to others. (The writer wishes to express his thanks to Drs. Margaret Merrell and J. W. Fertig for the helpful suggestions given.)

Description of the early developmental stages of the abnormal larva of D. medinensis

As stated before, a few abnormal *Dracunculus* larvae with a very short tail containing a long filiform appendage, were present along with the normal forms described before, in the same adult *D. medinensis.* The description given below refers to this abnormal larva designated as type A in a previous publication (Moorthy and Sweet, 1936 d). In table 1 the average measurements are given of the early first stage larva of this type and also of some of the later developmental stages, obtained from experimentally infected cyclops. In table 2, de Man's proportional measurements are given for α, β, and γ, and the location of the genital primorium is expressed as a percentage of total body length from the anterior extremity. The description and the measurements given are of the larvae fixed, stained and mounted by the author's method.

First stage larva (Pl. 2; figs. 5 to 9). Several hundred of the abnormal larvae, obtained from the same adult worm from which the normal larvae described before had been extracted, were studied. Average measurements of ten of them selected at random from the same slides which were used for the measurements of the normal larvae are given in tables 1 and 2.

Description. Body length 0.410 to 0.492 mm.; greatest width of body, slightly anterior to esophago-intestinal valve 0.017 to 0.025 mm.; $\alpha = 16.4$ to 28.2; $\beta = 3.2$ to 3.8; $\gamma = 4.9$ to 6.1; genital primordium, 56 to 72 per cent. Transverse cuticular striations, deep, distinct, and about 3 to 4 μ apart. Nerve ring 0.058 to 0.077 mm. from anterior extremity. Excretory pore, excretory cell nucleus, and intestines, same as in corresponding stage in normal type described above.

Genital primordium 0.25 to 0.35 mm. from anterior extremity; structure, same as in normal type (fig. 5). Rectum 0.02 to 0.033 mm. long. Anus 0.33 to 0.4 mm. from anterior extremity. Phasmids slightly posterior to anus. In general, the structure of the normal and the abnormal type in the portion of the body anterior to the anus was identical, but in the tail the following differences were observed:

1. The tail 0.081 to 0.1 mm. in length; short, thick, and only about half as long as that of normal type.

2. The tail does not taper gradually to a fine pointed tip as in the normal type but abruptly narrows to about one-third the anal diameter from about its middle and ends, posteriorly, with a stout, rounded tip.

3. In 25 to 30 per cent of the abnormal larvae there was a very conspicuous, blunt, knob-like process projecting dorsally from the body of the larvae at about 0.01 to 0.032 mm. from the anus (fig. 5); in the rest, the knob was not present, the general appearance of the tail in them being as shown in figure 6.

4. A long (about 0.095 to 0.13 mm. in length) filiform process with a blunt tip projects dorsally as an appendage from the tail, as shown in figures 5 and 6, from about 0.05 to 0.06 mm. from the anus. It is mainly the presence of this extra appendage in the abnormal type and its entire absence in the normal type that differentiates one type from the other. This appendage is undoubtedly a true projection from the body since, as shown in figures 5 and 6, the cuticle and the endoplasm of the appendage is continuous with that of the rest of the body.

Out of several thousands of *D. medinensis* larvae that have been examined so far the most frequent abnormality (1 in 900) observed in the tail was that illustrated in figures 5 and 6. Other very rare abnormalities (1 in several thousand) noticed in the tail, that neither resembled the normal nor the abnormal type, are illustrated in figures 7, 8, and 9.

Late first stage larva in cyclops undergoing the first molt (Pl. 3; fig. 14). Large numbers of cyclops were infected with fresh *Dracunculus* larvae, containing both the normal and the abnormal type; about 3 to 6 days after infection they were carefully dissected and examined for the abnormal type of the larvae undergoing the first molt. Several thousands of cyclops were examined but so far only three larvae of this type undergoing the first molt have been obtained. The average measurements of these three larvae are given in tables 1 and 2.

Description. In general structure this larva resembles the corresponding stage of the larva of the normal type in the portion of the body anterior to the anus. In the tail region the following were the differences noted:

1. The long, filiform, dorsal appendage was just being separated from the body; it was degenerated and probably will be cast off with the exuviae of the first molt (fig. 14).
2. The dorsal knob present in some of the specimens of early first stage larva was not present.
3. The variation in length of the tail between the early first stage larva and the late first stage in the abnormal type was not so marked as in the normal type (table 1).
4. At the tip of the tail the mucrones observed in the corresponding stage of the normal type had not yet been formed (fig. 14).
5. The exuviae of the first molt was as distinct but that of the second molt was thinner, close to the body, and not so very distinct as in the corresponding stage of the normal type (fig. 14).

Second stage larva undergoing the second molt. Several thousand cyclops infected with the fresh larvae of both the normal and the abnormal types were examined at periods varying from 8 to 40 days after infection, but so far the abnormal type of larvae undergoing the second molt have not been obtained.

Third stage larva (Pl. 4; fig. 17). Out of several thousand infected cyclops examined about 3 weeks after infection, so far only one third stage larva, probably belonging to the abnormal type (as judged from the abnormality in its tail) was obtained. Structurally it is identical with the third stage larva of the normal type in the anterior portion of its body; but the following differences were noticed in the posterior region:

1. The rectum was tubular and only about half as long as that of the normal type.
2. There was a blunt, knob-like process directed slightly posteriorly and situated on the dorsal aspect of the tail about halfway from the anus. No such structure was present in the tail of the larva of the normal type.
3. The tail was of about the same width as that of the body in the anal region, up to the level of the knob, from where it abruptly narrows down and terminates in four bluntly pointed mucrones at the tip (fig. 17).
4. Except for a slightly posterior location, the genital primordium was structurally identical with that of the normal type.

It has not yet been possible to understand the exact significance of the structural variation noticed between the larvae of the normal and the abnormal types of *D. medinensis.* It is also not clear whether, in the first stage larva of the abnormal type, it is the short tail or the long filiform appendage in the tail that fulfills the function of the tail of the normal type. It is, however, of interest to note that the measurements of the tail, together with those of the appendage in the abnormal type corresponds approximately to the total length of the tail of the larva of the normal type. Since both the types have been obtained from the same adult worm they do not represent different species. Several hundred of the abnormal type were obtained from fifty patients in different infected villages in Chitaldrug District and also from one experimentally infected dog (Moorthy and Sweet, 1936 a). The abnormal. larvae were also observed to undergo definite metamorphosis in cyclops, like the normal type. Based on preliminary observations it had been suggested in a previous publication (Moorthy and Sweet, 1936 d) that the structural variations between the types were not a mere anatomical abnormality of no specific significance and that the two types possibly represented the sexes of the larvae of *D. medinensis.*

So far it has not been possible to obtain any definite evidence to support this view or to explain why there is such a wide variation (1–900) in the natural occurrence between the two types. If these two types represent the sexes of the *Dracunculus* larvae it also becomes difficult to explain why, in all the experimental dogs during the first 3 months after infection, the variation in the relative numbers of the males and females was only about 1 to 4 and not as great as between the early larval stages of the two types. The preponderance of females over males was, however, noticed in the later stages of infection in some of the experimental animals; but this was undoubtedly due to the death, degeneration, and absorption of some of the males after fertilizing the females.

An answer to this problem appears to be possible only after conducting a crucial experiment designed to follow the further developmental stages of the third stage larvae of the two types separately in the vertebrate host, some being infected only with the larvae of the normal type and the others only with the larvae of the abnormal type.

Summary

Some of the general observations on the infection of cyclops with the larvae of *D. medinensis,* are given. *M. leuckarti* and *M. hyalinus,* the species found infected in nature, were used in the laboratory infections. The results are recorded of the different experimental observations made to determine the various possible factors, such as atmospheric, chemical, physical, environmental and biological, that appeared to influence the normal development of the *Dracunculus* larvae in cyclops. The time necessary for the complete development of the larvae was found to be prolonged or the further development of the larvae was observed to be retarded or arrested when cyclops were infected, (*a*) with more than five larvae, (*b*) with the larvae that had been obtained from human beings after septic infection of the wound had occurred or (*c*) when the cyclops were first infected with *Camallanus* larvae and then superinfected with *Dracunculus* larvae. Retardation or arrest of development of the larvae was also observed when cyclops were infected with larvae weakened, previous to infection, by passage through the gastro-intestinal tract of certain species of fresh-water fish or with larvae kept for about an hour in 1 to 1000 acriflavine, 1 to 500 methylene blue, 0.2 per cent HCl or fresh fish bile. It has been observed that the infected cyclops live for a longer period in shallow dishes containing a small volume of water than in tall jars containing a larger volume of water. Since the level of water in step-wells is very low during the summer in the Chitaldrug District, it is suggested that this is probably another factor responsible for the transmission season of dracontiasis there being during the summer. When infected with the larvae of *D. medinensis,* the majority of female cyclops have been observed not to form fresh brood capsules (possibly due to pressure atrophy of the ovaries), however long they were kept in the laboratory. It is suggested that the development of at least a few immature cyclops to maturity is possibly retarded when they are infected with the larva of *D. medinensis.* A peculiar observation is recorded of the fresh first stage larvae of *D. medinensis* vomiting out their entire esophagus and intestines when placed in fixative solution containing 0.52 gms. of mercuric perchloride, 1.04 gms. of sodium chloride and 100 cc. of distilled water.

The detailed descriptions of the early first stage larvae of *D. medinensis* (both the normal and the abnormal types) and their further developmental stages in cyclops (*M. leuckarti* and *M. hyalinus*) are given. The larva of the normal type has been observed to undergo the first molt between the fifth and seventh day and the second molt between the eighth and twelfth day after infection of cyclops, in hot weather (90 to 102° F). In cooler weather (55 to 70° F), the corresponding molts have been observed to take place respectively between the eighth and twelfth day and between the thirteenth and sixteenth day after infection. The larva has been further observed to increase in size for about a week after it has completely shed the exuviae of the second molt. After this period no further development is noticed up to 107 days after the infection of the cyclops. The widest variation in length (0.24 to 0.608 mm.) was observed in the normal third stage larva. Since there was no structural variation between the shortest and the longest form, it is suggested that the variation in size is possibly due to the effect of some environmental or undetermined host-specific factor on the growth of the larvae and is probably not due to the sexual differentiation of the larvae taking place at this stage. The proposed experimental procedure to determine the possible significance, if any, of the structural variation between the normal and the abnormal types of the larvae of *D. medinensis* is also indicated.

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EXPLANATION OF PLATES

The following abbreviations are used in plates I to IV

D.O.L. = dilated oesophageal lumen.
O.N. = oesophageal nuclei.
E.C. = excretory cell.
D.I.L. = dilated intestinal lumen.
D. = dorsal denticle.
I.V. = interno-ventral papillae.
P.E. = papillae on the external circle.
I.L. = interno-lateral papillae.
Amp. = amphid.
I.D. = interno-dorsal papillae.
A. = anus.
Ph.ph. = phasmidial pouch.
Ph.p. = phasmidial pore.
Ph. = phasmid.
Ph.n. = phasmidial nucleus.
G.P. = genital primordium.
E.S. = exuviae of the second molt.
E.F. = exuviae of the first molt.
K. = dorsal knob.
M.oes. = muscular oesophagus.
G.oes. = glandular oesophagus.
E.P. =excretory pore.

PLATE I

FIGURE 1. Esophageal region and a portion of the intestinal regions, mid lateral view.

FIGURE 2. Continuation of body from figure 1, mid lateral view.

FIGURE 3. Head, *en face* view.

FIGURE 4. Phasmidial region, ventral view; shows the details of the structure of phasmids.

PLATE II

FIGURE 5. Posterior region of larva, showing the dorsal knob and the dorsal filiform appendage in the tail.

FIGURE 6. Posterior region; does not show the dorsal knob.

FIGURES 7, 8, and 9. Showing the other rare abnormalities noticed in the tail.

PLATE III

FIGURE 10. Cephalic portion of the normal larva undergoing the first molt.

FIGURE 11. Tail of the normal larva undergoing the first molt; shows the exuviae of the first molt just being shed and the exuviae of the second molt just being formed.

FIGURE 12. Cephalic portion of the normal larva undergoing the second molt.

FIGURE 13. Tail of the normal larva undergoing the second molt.

FIGURE 14. Tail of the abnormal larva undergoing the first molt.

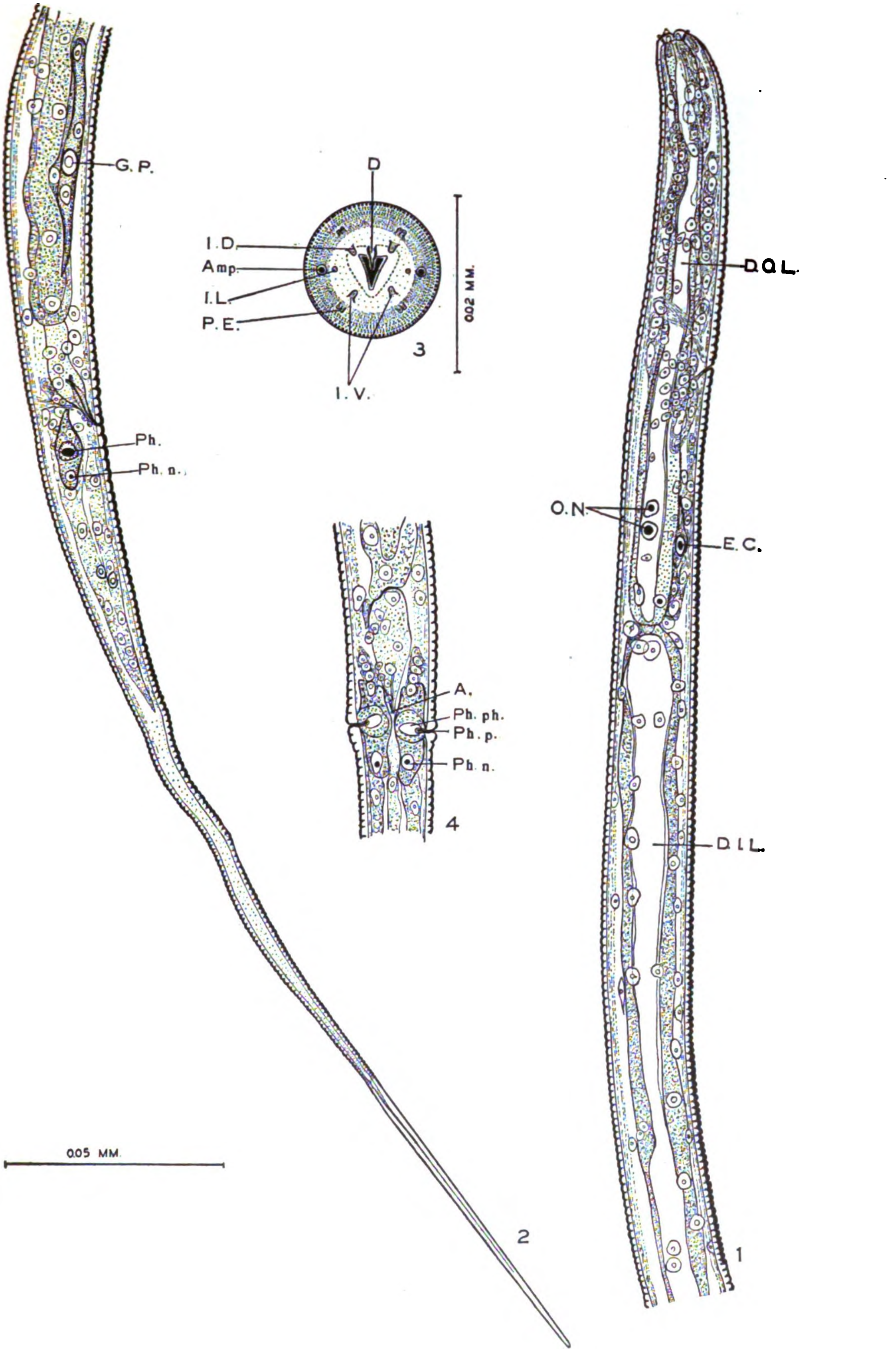
PLATE IV

FIGURE 15. Normal larva, lateral view. (There was slight torsion of the posterior portion of the esophagus.)

FIGURE 16. Normal larva, esophageal region, showing the excretory cell, the dorsal and sub-ventral esophageal glands with their conspicuous nuclei. (Normal appearance.)

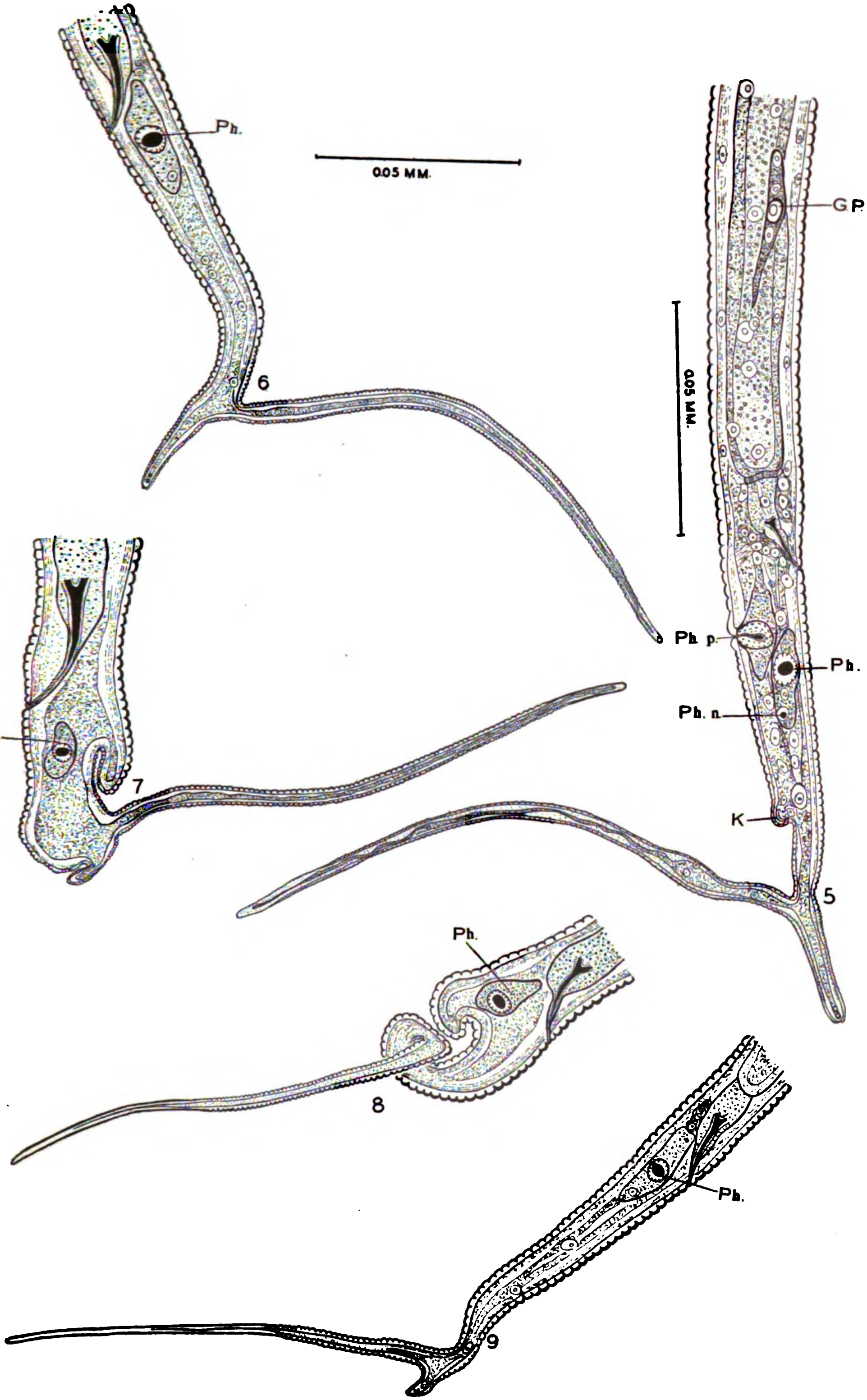
FIGURE 17. Tail of the third stage abnormal larva.

PLATE I



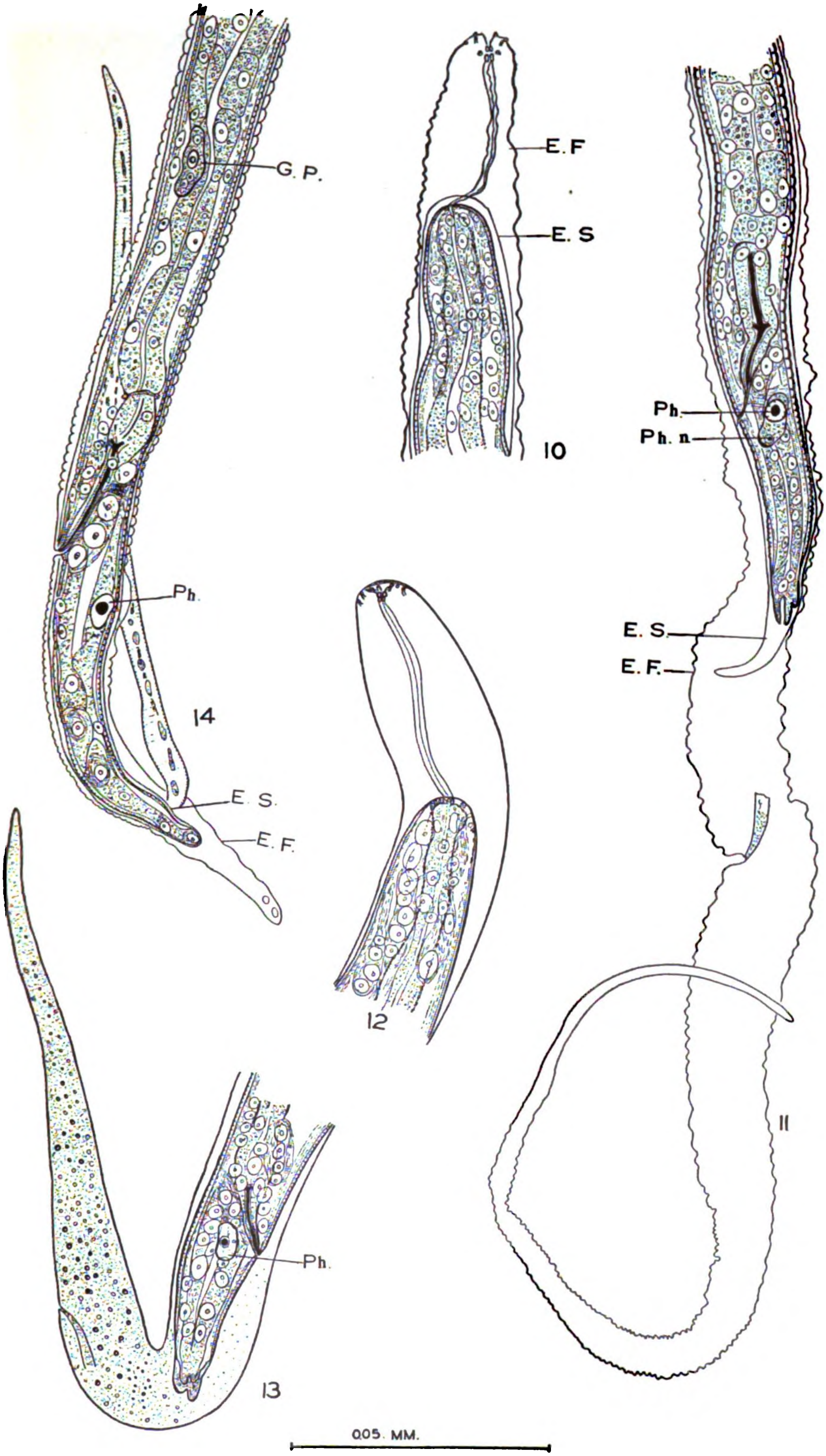
***First stage larva of* Dracunculus medinensis (*normal type*)**

PLATE II



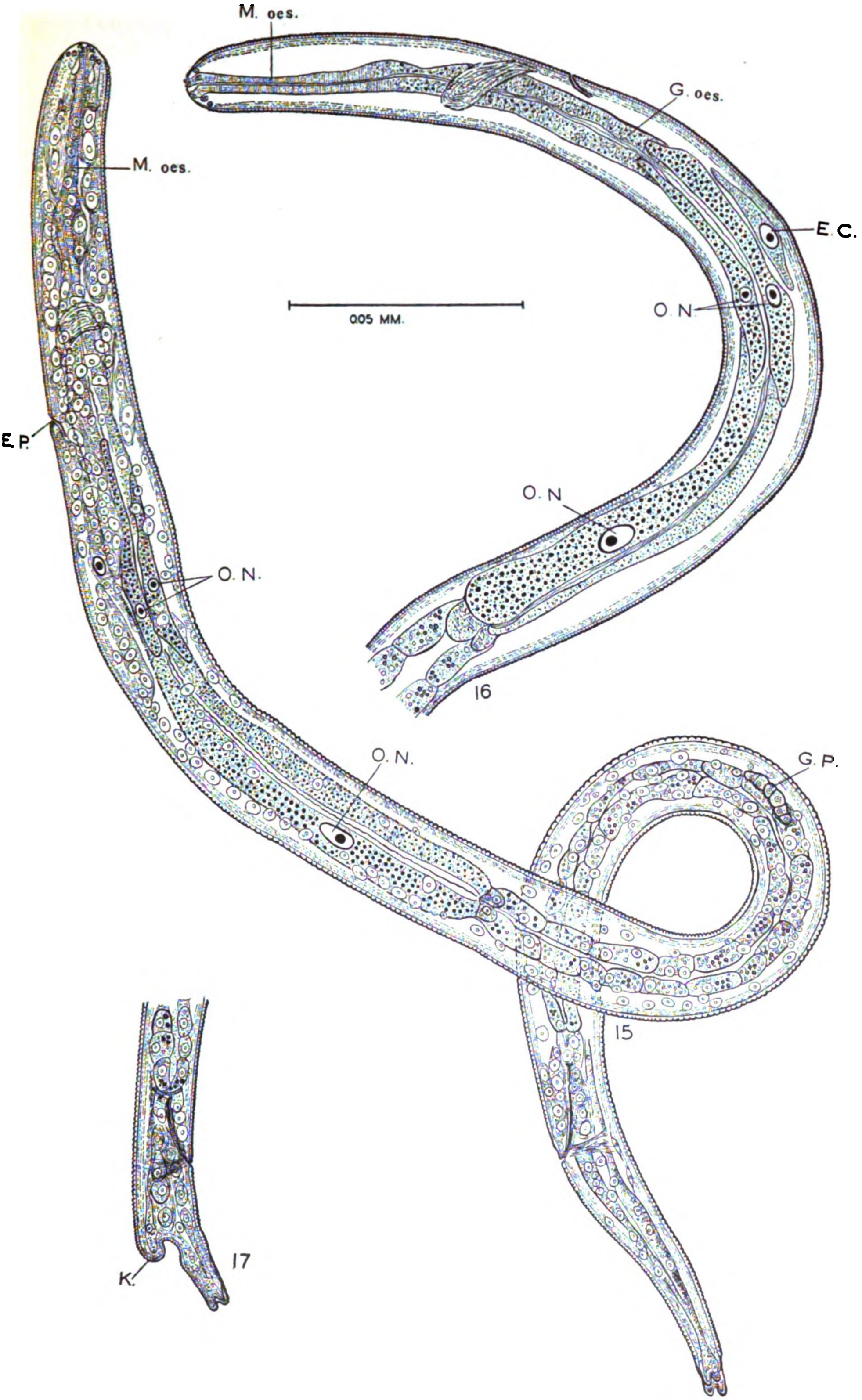
First stage larva of Dracunculus medinensis (*abnormal type*)

PLATE III



Developmental stages of the larvae of Dracunculus medinensis *obtained from the experimentally infected cyclops*

PLATE IV



Third stage larva of Dracunculus medinensis *obtained from the experimentally infected cyclops*

PLATE V

Figure 18. Dracontiasis patient; the blister is seen just forming near the ankle.

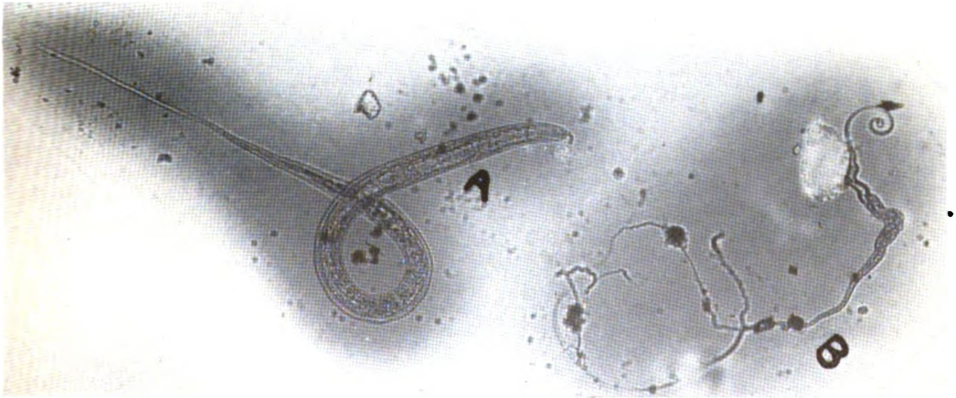


Figure 19. Fresh *Dracunculus medinensis* larvae treated with the fixative solution; *A, Dracunculus* larva that is just vomiting the esophagus; *B,* vomited portion of the entire esophago-intestinal region of the larva.

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OBSERVATIONS ON THE LIFE HISTORY OF *CAMALLANUS SWEETI**

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In a previous publication the writer (Moorthy, 1937b) gave a description of the adult of *Camallanus sweeti* and included a brief account of its life history, suggesting that this parasite requires the intervention of two intermediate hosts, cyclops and a smaller species of freshwater fish, before final development can take place in the definitive host, a freshwater fish, *Ophicephalus gachua*. The present paper records the general field and laboratory observations that have been made on the life history of the parasite. A brief description of developmental stages in the final and intermediate hosts is also given.

INCIDENCE OF INFECTION IN FISH

Of the five larger species of freshwater fish, *Mystus cavasius* (Ham), *Barbus sarana* (Ham), *Cirrhina fulungee* (Sykes), *Mastachembelus pancalus* (Ham), *Ophicephalus gachua* Ham, examined from different freshwater ponds in the Chitaldrug District, Mysore, India, only *O. gachua* was found to be infected (95 per cent) with adult *C. sweeti* under natural conditions. From the observations so far made this appears to be the only species of adult camallanid present in this fish.

FIRST INTERMEDIATE HOST

Nearly three thousand specimens of cyclops were examined from one of the freshwater ponds in which large numbers of infected *O. gachua* were present. Out of these only two were found infected, each with a single nematode larva. One of them (adult female *Mesocyclops leuckarti*) was infected with *Spiroxys* sp. and the other (adult female *Mesocyclops leuckarti* bearing ovisacs) with *Camallanus* sp. As mentioned subsequently, this larva differs structurally from the third stage larva obtained from cyclops infected in the laboratory with the first stage larva

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of *C. sweeti*. Further attempts to obtain specimens of cyclops infected with *Camallanus* larvae under natural conditions were unsuccessful. It seems curious that the infection of cyclops under natural conditions is so very scarce, though the infection of the definitive host under natural conditions is as high as 95 per cent. In the case of *Dracunculus* infection also, although 50–60 per cent of the people using a particular source of drinking water became infected with dracontiasis, attempts to obtain specimens of infected cyclops under natural conditions in water supplies had invariably proved unsuccessful until 1936. It was found out subsequently, however (Moorthy and Sweet, 1936), that infected cyclops could be obtained only when they were sought during the infective season when contamination of the water sources with fresh *Dracunculus* larvae was highest. This occurred when there were large numbers of very early blister stage cases of dracontiasis in the village. It is possible that in *Camallanus* infection, also, there is a particular period of the year when infection of cyclops is at its maximum, and it is probably only during this period that one would succeed in getting the infected cyclops. Since *O. gachua* normally lives in freshwater ponds containing large volumes of water, unless a large percentage of cyclops are infected it would be difficult to catch them in the usual representative collections made. It has been further observed in the laboratory that in the case of *C. sweeti* infections it is only the females of *M. leuckarti* bearing ovisacs that become infected easily. If this should be true under natural conditions also, then these specimens of infected cyclops, due to the weight of the larvae and the ovisacs, will have a tendency to remain at the bottom of the well. Consequently in wells containing large volumes of water, when using usual methods of collecting cyclops by means of a tow net, these infected specimens are possibly missed.

In the majority of freshwater ponds in Chitaldrug District, Mysore State, India, in addition to *O. gachua,* large numbers of the smaller species of cyclops-eating fish are also present. It appears likely that a large percentage of the infected cyclops are eaten by these smaller species of fish, as indicated, for instance, by a high incidence of infection of the third stage larva of *C. sweeti* (90 per cent) in *Lepidocephalichthys thermalis* (C.V.). This is probably another reason for the scarcity of infected cyclops under natural conditions.

M. leuckarti Claus and *M. hyalinus* Rehberg are the most common species of cyclops in the freshwater ponds of Chitaldrug District. Of these, adult female *M. leuckarti* bearing ovisacs appear to be more easily infected with *C. sweeti* under laboratory conditions than are those of *M. hyalinus*. In one experimental infection the following percentages of infection were observed: *M. leuckarti* bearing ovisacs 75 per cent; *M. leuckarti* (both mature and immature forms) 4 per cent; *M. hyalinus* (both mature and immature forms) 1 per cent.

The following observations have been made on the experimental infection of cyclops (*M. leuckarti* and *M. hyalinus*) with first stage larvae of *C. sweeti:*

1. Maximum percentage of infection was observed when large numbers of adult female *M. leuckarti* were placed in a small quantity of water containing fresh *Camallanus* larvae obtained from adult worms, the cyclops having been starved for 36 hours previous to infection by isolating them in distilled water.
2. When mature and·immature forms of both species of cyclops are used in the experiment only 25 to 30 per cent of them become infected, the rest being resistant, no matter how long they may be kept in contact with the larvae.
3. The cyclops become infected by swallowing the larvae. Four to eight hours after exposure to infection the larvae reach the body cavity where they undergo the early developmental changes described later.
4. A single cyclops may contain 12 to 15 larvae. These heavily infected individuals were sluggish and had a tendency to remain at the bottom of the container.
5. The longest period during which infected cyclops could be kept alive in the laboratory was 52 days in hot weather (90 to 102° F) and 70 days in cooler weather (55 to 70° F).
6. Attempts to infect cyclops with the third stage larvae obtained from other infected cyclops were always unsuccessful.
7. When specimens of cyclops infected with *Camallanus* larvae are superinfected with the fresh larvae of *Dracunculus medinensis,* it was observed that the latter underwent their usual developmental changes but the time required for this to take place was prolonged by 5–8 days. In a few instances the larvae developed only as far as the first or second molt, further development being completely arrested, although the cyclops remained alive for over 4 weeks in the laboratory. When, however, cyclops infected first with *Dracunculus* larvae were superinfected with fresh *Camallanus* larvae, the *Camallanus* larvae, except in a few instances, underwent complete development in approximately the same time as in cyclops not infected with *Dracunculus* larvae.
8. Cyclops infected with either *Camallanus* or *Dracunculus* larvae do not seem to develop fresh ovisacs. Infection with either species of nematode larvae seems to affect in some way (by pressure atrophy?) normal functioning of the genital system of cyclops.

EFFECT OF FRESH BILE (UNDILUTED) OR HYDROCHLORIC ACID (0.1 TO 1.0 PER CENT) ON CYCLOPS INFECTED WITH *Camallanus* LARVAE

Undiluted fresh bile of *O. gachua* killed cyclops in about five minutes and activated the larva in identically the same manner as in cyclops infected with *Dracunculus* larvae (Moorthy, 1935). The activated larva makes frantic efforts to break through the anterior and posterior antennae, legs and various segmental joints of the cephalothorax and abdomen. It is only when the larva reaches the caudal ramus or the anal segment that it succeeds, like the *Dracunculus* larva, in escaping through a hole made there apparently by the persistent cutting and screwing movements of its oral extremity. Activation of the larva was observed in 108 specimens of infected cyclops treated with bile, but in only three instances did larvae succeed in escaping through the anal segment. The time taken for the larvae to escape varied from 50 minutes to 2 hours. When larvae did not succeed in breaking through the exoskeleton they usually died in the body cavity of the cyclops after 3–4 hours of active motion.

Fresh bile from *Barbus* (*Puntius*) *ticto* (Ham) and *Barbus puckelli* Day had the same effect as that of *O. gachua:* the cyclops were killed in one to two minutes. Of 32 infected cyclops treated with these biles, escape of larvae through anal segment or caudal ramus took place in four instances, at intervals varying from 48 minutes to 3 hours.

Bile of goat, sheep, and dog killed cyclops in 25 to 30 minutes; the larvae were activated only slightly, and in none of 20 specimens of infected cyclops treated in this way did the larva succeed in escaping.

A solution of preserved ox bile in distilled water in strengths varying from 10 to 20 per cent had little or no effect on the infected cyclops. It did not kill them for nearly three hours, and the activation of the larvae was not observed in any of the 20 specimens treated with this solution.

Hydrochloric acid in strengths varying from 0.1 to 1.0 per cent killed the cyclops in two to three minutes, but the *Camallanus* larvae, unlike the *Dracunculus* larvae, were only slightly activated. Escape of larvae was not observed in any of 20 specimens of cyclops treated.

The stimulation of *Camallanus* larva to activity by fresh bile seems to be definite since it was observed in all the specimens studied. Actual escape of the larva appears to be by chance depending possibly on the degree of digestion and softening of the exoskeleton of cyclops effected by the bile. In the laboratory, of 140 infected cyclops treated with fresh fish bile the larvae escaped from only seven. In the fish, however, it is likely that this release of larvae takes place easily and freely by the complete breakdown of the exoskeleton of cyclops during the usual processes of digestion.

SECOND INTERMEDIATE HOST

In the course of certain other investigations on the "biological method of control of dracontiasis," the following four species of small cyclops-eating freshwater fish were found to contain in their intestines, under natural conditions, the third stage larvae of *C. sweeti: Barbus puckelli*

Day, 20 per cent; *Barbus* (*Puntius*) *ticto* (Ham), 15 per cent; *Lepidocephalichthys thermalis* (C.V.), 90 per cent, and *Gambusia* sp. (introduced from Italy), 5 per cent. The larvae found in *B. ticto* and *Gambusia* were structurally identical with the third stage larva of *C. sweeti* from experimentally infected cyclops. In *B. puckelli* and *L. thermalis,* in addition to the larval stage found in cyclops a few were found (3 and 42 per cent respectively) that had undergone certain further developmental changes to be described later.

DEFINITIVE HOST

In the final host, *O. gachua,* infected under natural conditions the following different developmental stages of *C. sweeti* were found in the intestines: first stage larvae (1 per cent); third stage larvae, in the same stage of development as in experimentally infected cyclops (3 per cent); late third stage larvae in the same stage of development as in *B. puckelli* and *L. thermalis* (10 per cent); late fourth stage larva (0.5 per cent); early fifth stage larva (0.5 per cent); mature adult females (92 per cent); mature adult males (99 per cent).

DESCRIPTION OF THE DEVELOPMENTAL STAGES OF *C. sweeti*

Specimens of first stage larvae were obtained from the mature *C. sweeti* taken from *O. gachua.* The different developmental stages in cyclops came from experimentally infected cyclops. The stages described from the second intermediate and final hosts were from fish infected under natural conditions. The measurements of the larvae in different developmental stages, are summarized in table 1. In table 2 de Man's proportional measurements are given for α = total length/body width, β = total length/esophagus length and γ = total length/tail length. The location of the genital primordium or vulva from the anterior extremity is given as a percentage of total body length. It is seen from the table that as the first stage larva grows to the adult (early fifth stage) the value of α and γ steadily increases, suggesting that increase in body length is proportionally greater than corresponding width of body or of length of tail. There is not, however, much variation in the value of β for different developmental stages, suggesting that increase in length of esophagus is in proportion to increase in body length in different developmental stages of *C. sweeti.* Description and measurements are from specimens fixed and preserved in 2 per cent formalin or fixed, stained, and preserved by the author's method (Moorthy, 1937a).

First stage larva (Plate I, figs. 1 and 2). Measurements given in tables 1 and 2 are the average of 10 specimens selected at random.

TABLE 1.—*Measurements of different developmental stages of* Camallanus sweeti

No.	Stage of development of larvae	Speci-mens examined	Speci-mens mea-sured	Body measurements (in mm)									
				Total length	Greatest width	Stoma	Nerve ring (from anterior end)	Excretory cell or pore (from anterior end)	Anterior[1] esophagus	Posterior[2] esophagus	Genital primordium or vulva (from anterior end)	Anus (from anterior end)	Tail length
1	1st stage larva	large number	10	0.24	0.014	....	0.03	0.09 (EC)	0.04	0.02	0.14 (GP)	0.20	0.04
2	Late 1st stage larva, molting	1	1	0.26	0.014	....	0.03	0.09 (EC)	0.05	0.02	0.15 (GP)	0.22	0.04
3	Early 2nd stage larva	1	1	0.41	0.023	0.007	0.04	0.05 (EP)	0.05	0.07	0.23 (GP)	0.37	0.04
4	2nd stage larva, molting	10	3	0.42	0.031	0.015	0.04	0.05 (EP)	0.08	0.08	0.23 (GP)	0.39	0.03
6	3rd stage larva (from experimentally infected cyclops)	large number	10	0.56	0.035	0.034	0.08	0.08 (EP)	0.16	0.10	0.37 (GP)	0.52	0.04
7	Developed 3rd stage larva in 2nd intermediate host (natural infection)	large number	4	0.74	0.034	0.035	0.08	0.08 (EP)	0.17	0.14	0.46 (GP)	0.70	0.04
9	Late 4th stage larva, molting (natural infection from intestine final host)	1	1	1.25	0.046	0.035	0.09	0.11 (EP)	0.20	0.20	0.70 (V)	1.20	0.06
10	Early 5th stage larva (natural infection from intestine final host)	1	1	1.98	0.060	0.046	0.10	0.12 (EP)	0.24	0.28	1.17 (V)	1.93	0.06

[1] Anterior portion of esophagus, from anterior end to commencement of glandular portion.
[2] Posterior portion of esophagus, from commencement of glandular portion to esophago-intestinal valve.
EC = excretory cell; EP = excretory pore; GP = genital primordium; V = vulva.

TABLE 2.—*de Man's proportional measurements of* C. sweeti

No.	Stage of development of larvae	α Total length	β Total length	γ Total length	Vulva or genital primordium per cent of body length from anterior end
		Body width	Esophagus length	Tail length	
1	1st stage larva	17	3.6	6	58 (GP)
2	Late 1st stage larva, molting	19	3.6	7	59 (GP)
3	Early 2nd stage larva	18	3.6	12	57 (GP)
4	2nd stage larva, molting..	14	2.6	14	55 (GP)
6	3rd stage larva (from experimentally infected cyclops)	16	2.2	14	65 (GP)
7	Developed 3rd stage larva in 2nd intermediate host (natural infection)	22	2.3	18	63 (GP)
9	Late 4th stage larva, molting (natural infection from intestine final host)	27	3.1	22	56 (V)
10	Early 5th stage larva (natural infection from intestine final host)	33	3.8	33	59 (V)

Same number of specimens measured as in table 1.
GP = genital primordium ; V = vulva.

Description. Body 0.19 to 0.28 mm long and 0.012 to 0.018 mm wide. $\alpha = 15$ to 24, $\beta = 3$ to 5, $\gamma = 5$ to 7, genital primordium 53 to 65 per cent. Transverse cuticular striations fine; stoma small and narrow; characteristic dorsal triangular denticle present on the anterior extremity (fig. 1); amphids pore-like; esophagus, consisting of two parts, anterior muscular portion 0.027 to 0.062 mm in length and posterior glandular portion 0.012 to 0.030 mm in length (fig. 1); nerve ring 0.025 to 0.045 mm from cephalic extremity; excretory cell 0.080 to 0.121 mm from cephalic extremity, at about level of proximal one-fourth of intestine; excretory pore not distinct, apparently situated slightly anterior to the excretory cell nucleus (fig. 1); intestine consisting of 16 to 24 cells arranged in transverse rows of two to three cells (fig. 1); genital primordium 0.11 to 0.17 mm from the anterior extremity, consisting of four cells arranged in a longitudinal row and situated close to the intestinal wall; anus 0.15 to 0.22 mm from anterior extremity; phasmids large, pouch-like, slightly posterior to anus (fig. 1); tail 0.033 to 0.046 mm long terminating with a bluntly pointed tip.

In only a few of the first stage larvae of *C. sweeti* studied was it possible to differentiate the anterior muscular from the posterior glandular portion of the esophagus; in the majority of the other specimens the general appearance is indicated in fig. 2. Since this demarcation between the muscular and glandular esophagus has been observed in only a few preserved specimens of larvae, this observation needs confirmation.

Late first stage larva undergoing the first molt (Plate I, fig. 4). The first molt appears to take place 24 to 36 hours after the larva gains entrance into the body cavity of the cyclops. It is extremely difficult to recognize this molt since it occurs at such a short interval after infection; the exuviae are very thin and lie quite close to the cuticle of the larva. Of several specimens examined this molt was distinct in only one.

Description. The different measurements of the larva at this stage are given in tables 1 and 2. The general structure of the larva is about the same as the early first stage larva, with the following differences:

1. The anterior end is globular and devoid of the dorsal triangular denticle which appears to be lost with the exuviae (fig. 4).
2. The stoma is wider and more distinct.
3. The demarcation between the muscular and glandular portion of the esophagus is slightly more distinct.
4. The total number of cells in the intestine is about 35 cells.
5. The posterior end is thicker and more bluntly pointed.

Early second stage larva (Plate I, figs. 3 and 5). Only one specimen was available for study. This was obtained from the body cavity of cyclops, about 52 hours after infection.

Description. The different measurements of this specimen are given in tables 1 and 2. The following differences were noticed between this stage and the previous late first stage:

1. The stoma is very distinct and rectangular in shape (fig. 3).
2. A pair of very prominent esophageal nuclei is present (fig. 3).
3. The excretory pore is distinct and situated slightly posterior to the nerve ring (fig. 3).
4. The tail is short compared to the total body length, and is bluntly pointed at the tip (fig. 5).

Late second stage larva undergoing the second molt (Plate II, figs. 6 and 7). The larva undergoes the second molt between the 5th and 7th day during hot weather (90° to 102° F.) and between the 8th and 12th day during the cooler weather (55° to 70° F.). This molt unlike the first, was easily recognized and observed in a number of specimens.

Description. Average measurements of three specimens are given in tables 1 and 2. This stage resembles the third stage larva very closely but differs from the first stage larva in the following respects:

1. The stoma is completely formed; buccal cavity partially chitinized and separates the imperfectly chitinized jaws from the esophagus (fig. 7). The molted portion of the old stoma and esophagus is present in the anterior portion of the exuviae to be cast off.
2. The amphids are situated at the anterior margin between the two pairs of partially chitinized quadrilateral plates.
3. The external circle of two pairs of papillae is conspicuous (fig. 7).
4. The demarcation between the muscular and glandular esophagus is very distinct (fig. 7).
5. The excretory pore is distinct and situated slightly posterior to the nerve ring.
6. The intestine consists of 40 to 50 cells arranged in transverse rows of 2 to 3 cells each.
7. The genital primordium consists of four cells as in the previous stages. It is elliptical, nearly as long, but twice as broad, as in the earlier stages.
8. The rectum is just undergoing the molt (fig. 6).
9. The tail is short compared to body length and covered by the posterior portion of the exuviae to be cast off. Three characteristic mucrones are present at the tip (fig. 6).

Third stage larva (from experimentally infected cyclops) (Plate II, figs. 8, 9, and 10). Specimens of cyclops were infected with the first stage larvae of *C. sweeti* and had remained alive in the laboratory for over three weeks. The description is of larvae obtained from them.

Description. Average measurements of 10 specimens are given in tables 1 and 2. Body 0.47 to 0.65 mm long and 0.032 to 0.040 mm wide; $\alpha = 14$ to 18; $\beta = 2.0$ to 2.4; $\gamma = 12$ to 16; genital primordium 61 to 70 per cent; stoma, 0.030 to 0.037 mm long, well formed; buccal cavity partially chitinized, separating imperfectly chitinized jaws from esophagus; 8 to 11 partially chitinized, beaded ridges of almost the same length, extend from anterior margin to about the level of buccal cavity; amphids situated at anterior margin, between two pairs of partially chitinized quadrilateral plates; two pairs of papillae of external circle conspicuous (fig. 10); esophagus with anterior muscular portion 0.14 to 0.17 mm in length and posterior glandular portion 0.09 to 0.12 mm in length, demarcation between the two portions quite distinct; nerve ring 0.06 to 0.09 mm from anterior extremity; excretory pore slightly posterior to nerve ring; excretory cell conspicuous, situated at about level of base of muscular portion of esophagus (fig. 8); intestine consisting of 48 to 56 cells, containing large number of yellowish brown granules and transparent globules; genital primordium ellipsoidal in shape, 0.30 to 0.41 mm from anterior extremity, containing about eight cells nearly as long but about twice as broad as those of first stage larva (fig. 8); anus 0.43 to 0.61 mm from anterior extremity; tail 0.035 to 0.051 mm long, with three characteristic unequal mucrones present at tip, the mediodorsal being noticeably stouter than the other two (fig. 9); phasmids circular, posterior to anus (fig. 9).

Third stage larva found in intestines of B. puckelli *and* L. thermalis *under natural conditions* (Plate III, fig. 11). In the intestines of *B. puckelli* and *L. thermalis,* third stage larvae in the same stage of development as those found in experimentally infected cyclops, and also a few that appeared to have undergone further development in the fish, were found under natural conditions. Measurements and description given are of the latter forms that appeared to have undergone further developmental changes in the fish host.

Description. In structure this larva resembles very closely the third stage larva from experimentally infected cyclops except for the following differences:

1. It is about one and a half times as long and nearly as broad as the third stage larva from cyclops.
2. Jaws, buccal cavity, quadrilateral plates, and longitudinal ridges are nearly completely chitinized while in third stage larva from cyclops they are partially chitinized (fig. 11).
3. Ratio between length of anterior portion and posterior portion of esophagus is less than that in third stage larva from cyclops, and approximates more that of later developmental stages.
4. Genital primordium consists of eight cells, but is nearly one and a half times size in third stage larva from cyclops.
5. Intestine contains larger numbers of cells (about 80) than in third stage larva from cyclops.

Third stage larva undergoing third molt. In spite of repeated careful search for the third stage larva of *C. sweeti* undergoing the third molt, none has been secured from either intermediate or definitive hosts. Hence neither larval structure at this stage of development nor host in which the third molt takes place, could be determined. It seems likely that the third molt takes place in the intestine of the second intermediate host.

Fourth stage larva undergoing fourth molt from intestines of O.

gachua *infected under natural conditions* (Plate III, figs. 15 and 16). Out of several specimens of *O. gachua* that were examined only a single specimen of *Camallanus* larva undergoing (?) the fourth molt was obtained. Judging from the structure of the old stoma which was just being cast off and of the new one just being formed, it was thought at first to be undergoing the third molt. However, structure of genital primordium and already formed vulva suggested further development than the third stage and it is described as undergoing the fourth molt.

Description. Measurements are given in tables 1 and 2. The following distinctive developmental changes were observed:

1. Both the old stoma (resembling that of early third stage larva) just being shed, and the new one resembling that of the adult just being formed (fig. 15).
2. Number of cells in intestines has increased to about 120.
3. Genital primordium is conspicuous and considerably increased in size. Its length is 10 to 12 times and breadth 3 to 4 times that of the late third stage larva.
4. Vulva, vagina, and uterus are just being differentiated and sex can be easily recognized.
5. Tail is short and three characteristic mucrones are present at tip (fig. 16).

Early fifth stage larva (Plate III, fig. 17). Only one specimen was found in the intestines of *O. gachua* infected under natural conditions.

Description. The different measurements of the specimen are given in table 1. In general structure this stage resembles that of adult *C. sweeti* (Moorthy, 1937), except for the following differences:

1. Stoma is only partially chitinized and new longitudinal ridges are just being formed (fig. 17).
2. Intestine consists of about 200 cells.
3. Vulva and vagina are fully formed, but lips of vulva are not so prominent and do not project out from body as in adult.
4. Anterior and posterior portion of uterus is just being differentiated, the anterior end terminating in a long tubular ovary and the posterior in a small rudimentary ovary.

DISCUSSION OF LIFE HISTORY

In some of the specimens of *O. gachua,* a few of the dead adult females of *C. sweeti* that had completely emptied their uteri of larvae were present; and in a few others, living first stage larvae were found in the lower half of the intestine. It is suggested from these observations that under natural conditions the adult female worms discharge the larvae into the lumen of the intestine of *O. gachua,* the worms dying after all the larvae have been discharged. On reaching the water in the feces of the fish, the larvae are swallowed by a suitable species of cyclops, possibly adult females of *M. leuckarti,* and reach the body cavity of cyclops about two to three hours after infection; about 24 to 36 hours later, these larvae undergo the first molt; and after 5 to 7 days during hot weather or 8 to 12 days in the cooler weather they undergo the second molt. If at this stage the infected cyclops are ingested by a suitable freshwater fish, *B. puckelli* or *L. thermalis,* they are killed by the digestive secretions, e.g., the bile, and the larvae are activated; on being released from the cyclops certain further development including possibly the third molt of the larvae takes place in the intestine of the fish. As has been stated, specimens of larvae undergoing the third molt have not been found, either in the second or in the final host. The infection of the final host possibly takes place by its feeding on the second intermediate host. The larvae undergo the fourth molt in the intestines of the final host where a distinct change takes place in the stoma from the early larval *Paracamallanus* type to the adult *Camallanus* type. After this molt the larvae become sexually mature. Copulation appears to take place in the first half of the intestine, as large numbers of males and females were usually found in that region. The impregnated females migrate to the lower half of the intestines where they discharge the larvae, which on reaching the water in the feces of the fish, are ingested by cyclops and the life cycle is started again.

In the laboratory it has so far been possible to follow the life history of *C. sweeti* only in the first intermediate host, the cyclops. Since both the second intermediate and final host are very heavily infected with this parasite under natural conditions in the locality where the investigation was conducted, it was not possible to follow the life history of the parasite in these hosts in the laboratory. Structural identity of larval forms obtained from the second intermediate and final host, with those obtained from cyclops experimentally infected with first stage larva of *C. sweeti,* give adequate support to the life history suggested.

Since it was not possible to follow the life history of *C. sweeti* in the second intermediate and final hosts in the laboratory, it is difficult at the present stage of the investigation to estimate how far the intervention of the second intermediate host is necessary for the infection of the final host and whether or not the final host can become infected by feeding directly on the first intermediate host. The presence of the third stage larva in the intestines of the definitive host (3 per cent) showing the same stage of development as in cyclops suggests that the final host gets the infection by feeding directly on cyclops; but the presence in the intestines of the final host also of the later developed stage found in the second intermediate host suggests that the early third stage larva is possibly introduced by the final host feeding on the second intermediate host which harbors both the stages of the larvae and not by feeding directly on cyclops. In addition, it has been observed in the field that *O. gachua* does not feed to any great extent on cyclops directly, but feeds voraciously on the smaller cyclops-eating fish, especially *L. thermalis,* in which the highest percentage (42 per cent) of the late third stage larval infection of *C. sweeti* was observed under natural conditions. The largest percentage

(10 per cent) of the early developmental stage of *C. sweeti* found in the intestine of *O. gachua* are structurally identical with the stage of maximum development of *C. sweeti* in the intestines of the second intermediate host. Adult *C. sweeti* have so far been found only in *O. gachua* which feeds essentially on the second intermediate host, and not in any of the other species of fish that feed voraciously on cyclops and other copepods. It is suggested from these observations that under natural conditions the infection of the final host does not take place without the intervention of the second intermediate host.

The most interesting feature in the life history of *C. sweeti* is the transformation of the stoma from the *Paracamallanus* type found in the third stage larva to the *Camallanus* type found in the adult when the larva undergoes the fourth molt in the intestines of *O. gachua*. As has already been pointed out (Moorthy, 1937b), the presence or absence of a large buccal cavity does not appear to be a satisfactory generic character and it is possibly superfluous to keep *Paracamallanus* as a separate genus.

UNDETERMINED FORMS OF CAMALLANID LARVAE

Camallanid larva from naturally infected cyclops (Plate IV, figs. 18, 19, and 20). As has been stated, the third stage *Camallanus* larva obtained from a single specimen of cyclops infected under natural conditions seems to be structurally different from the third stage larva of *C. sweeti* obtained either from the second intermediate host or from cyclops experimentally infected in the laboratory. Since this was the only camallanid larva so far found in cyclops collected from ponds containing large numbers of *O. gachua* infected heavily with *C. sweeti*, a brief description of this larva is given. The adult of this species of *Camallanus* has so far not been found in any of the fish hosts examined. It is possible that some other aquatic animal (turtle ?) is the final host of this species of *Camallanus*.

Description. Body 1.09 mm long by 0.07 mm wide; $\alpha = 16$, $\beta = 2.8$, $\gamma = 23$, genital primordium 66 per cent; stoma 0.046 mm long, consisting of an almost completely chitinized buccal cavity and well developed paired jaws (fig. 19); 14 longitudinal ridges, not beaded and of unequal length, extend from the cephalic extremity to the upper margin of the chitinous ring; two pairs of papillae of external circle conspicuous; amphids situated at the anterior margin between the two pairs of completely chitinized quadrilateral plate; cuticular striations transverse deep, distinct, and about 4 μ apart; esophagus with anterior muscular portion 0.26 mm long and posterior glandular portion, 0.14 mm long, the demarcation between the two portions quite distinct (fig. 18); nerve ring 0.13 mm from the anterior extremity; excretory pore slightly posterior to nerve ring; excretory cell nucleus at base of muscular portion of esophagus; intestine consisting of 65 cells arranged in transverse rows of three to four cells each, containing yellowish brown granules and transparent globules (fig. 18); genital primordium, 0.72 mm from the anterior extremity; consists of four cells arranged longitudinally (fig. 18); anus 1.05 mm from the anterior extremity; phasmids circular, situated slightly posterior to anus (fig. 20); tail 0.46 mm long; three very prominent equal mucrones are present at the tip (fig. 20).

This larva differs from the third stage larva of *C. sweeti* obtained from experimentally infected cyclops and also the early third stage larva obtained from the intestines of the second intermediate host infected under natural conditions as follows:

1. The chitinization of the buccal cavity, the jaws, and the longitudinal ridges is nearly complete, while it is only partial in larvae obtained from cyclops or fish.
2. The buccal cavity is only half as long as in the other forms.
3. The larvae are nearly twice as long and broad as those obtained from experimentally infected cyclops.
4. The transverse cuticular striations are deeper, more pronounced, and farther apart.
5. The genital primordium is longer and narrower, situated more posteriorly, and has only four cells.
6. The three mucrones at the tip of the tail are almost equal in size, while they are unequal in *C. sweeti,* the mediodorsal one being noticeably stouter and longer than the other two.
7. The ridges at the anterior margin of the stoma are 14 in number, unequal and are not beaded, while there are usually not more than 11 ridges of about the same length, every one of them distinctly beaded, in the third stage larva of *C. sweeti.*

These differences in the structure of this larva suggest that it probably represents the third larval stage of a different species of *Camallanus.* The exact identification of the species was not possible as only one larva was available for study and its structure did not agree with any of the known adults of this genus.

Encysted camallanid larva found in the second intermediate host (Plate III, figs. 12, 13, and 14). In about 5 per cent of *B. puckelli* and 18 per cent of *L. thermalis,* infected under natural conditions, an encysted camallanid larva (fig. 12) was found in the body cavity of the fish, in addition to the third stage larvae of *C. sweeti* that were found in the intestinal lumen. These encysted forms have also been found in about 2 per cent of *O. gachua.* In the smaller species of fish these forms were found encysted in the body cavity of the fish lying loosely attached to the intestines; in *O. gachua* they were always found in the lumen of the foregut, some being enveloped in the cyst and others being set free from it. This observation suggests that the encysted form is one of the early developmental stages of a camallanid, which when introduced into the intestines of *O. gachua* excysts and possibly does not undergo any further development. Structurally these forms appear to be different from any of the developmental stages of *C. sweeti* so far known.

Description. Body 1.1 to 1.6 mm in length, 0.05 to 0.06 mm in width; $\alpha = 17$ to 26, $\beta = 2.8$ to 3.9, $\gamma = 16$ to 23, genital primordium 50 to 64 per cent; stoma 0.035 to

0.048 mm in length; buccal cavity very narrow, being only half as long as that found in the third stage larva; longitudinal ridges observed in the later developmental stages of *C. sweeti* not present; two pairs of papillae of external circle, conspicuous; amphids situated at the cephalic extremities between the two pairs of chitinized quadrilateral plates (fig. 14); esophagus with anterior muscular portion 0.19 to 0.22 mm long and posterior glandular portion 0.16 to 0.22 mm long; nerve ring 0.09 to 0.11 mm from the cephalic extremity; excretory pore slightly posterior to nerve ring; intestine with 100 to 120 cells arranged in transverse rows of three to four cells each, containing a large number of yellowish brown granules; genital primordium nearly three to four times as long and about twice as broad as that of the third stage larva; anus 1.0 to 1.5 mm from the anterior extremity; tail 0.063 to 0.081 mm long, bluntly conoid, without mucrones (fig. 13).

The peculiar shape of the stoma, neither resembling the early larval stages nor that of the adult of *C. sweeti,* the entire absence of longitudinal ridges in the stoma and the absence of the characteristic mucrones at the tip of the tail which are present both in the early stages and in the mature adults of *C. sweeti,* suggest that these encysted forms represent a developmental stage of a different species of camallanid. Since *C. sweeti* is the only species of adult camallanid that has so far been found in *O. gachua,* it appears to be probable that the adult of this species is present in some other final host. Beyond excystation no further development of this encysted form is observed in *O. gachua.* The presence of these forms in *O. gachua* is possibly only accidental due to its feeding on *B. puckelli* and *L. thermalis* that harbor this encysted form.

SUMMARY

A description is given of the different developmental stages of *C. sweeti* (except that of the third stage larva undergoing the third molt) as they occur in the intermediate and the final host. There is also described a camallanid larva of unknown species found in the body cavity of naturally infected cyclops, and an encysted camallanid larva of unknown species found in the peritoneal cavity of *B. puckelli* and *L. thermalis.* It is suggested that in the life history of *C. sweeti* the intervention of two intermediate hosts, the cyclops and a freshwater fish (*B. puckelli* or *L. thermalis*) are necessary. Since under natural conditions there was heavy infection in the second intermediate and final host, it was not possible to follow the life history of *C. sweeti* in these hosts in the laboratory. It has been observed that fresh bile has identically the same effect on cyclops infected with *Camallanus* larva as on cyclops infected with *Dracunculus* larva, in both cases the cyclops being killed and the encysted larva activated.

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EXPLANATION OF PLATES

ABBREVIATIONS

Amp. .... Amphid
C.P. .... Cephalic papillae
D. ...... Dorsal denticle
Ec.n. .... Excretory cell nucleus
E.P. ..... Excretory pore
G.P. ..... Genital primordium
N.R. .... Nerve ring
N.S. .... New stoma just forming
O.N. .... Esophageal nuclei
O.S. ..... Old stoma just being cast
Ph. ...... Phasmid
St. ...... Stoma

PLATE I

Camallanus sweeti

FIG. 1. First stage larva: the general appearance observed in a few specimens in which the line of demarcation between the muscular and glandular esophagus was distinct.

FIG. 2. First stage larva, esophageal region: the general appearance observed in the majority of the larvae studied; here the line of demarcation between the muscular and glandular esophagus is not distinct.

FIG. 3. Early second stage larva: esophageal region.

FIG. 4. Late first stage larva undergoing the first molt: esophageal region.

FIG. 5. Early second stage larva: posterior region.

PLATE II

Developmental stages of *Camallanus sweeti* from experimentally infected cyclops.

FIG. 6. Second stage larva undergoing the second molt: posterior region.

FIG. 7. Second stage larva undergoing the second molt: esophageal region, lateral view.

FIG. 8. Third stage larva: general lateral view.

FIG. 9. Third stage larva: tail, lateral view.

FIG. 10. Third stage larva: cephalic region, lateral view.

PLATE III

FIG. 11. Late third stage larva obtained from the intestines of the second intermediate host: cephalic region.

FIG. 12. Encysted camallanid larva (sp. ?) found in the peritoneal cavity of the second intermediate hosts and also in the intestines of *O. gachua.*

FIG. 13. Tail of encysted camallanid larva (sp. ?).

FIG. 14. Cephalic portion of the encysted camallanid larva (sp. ?).

FIG. 15. Fourth stage larva of *C. sweeti* undergoing the fourth molt (from the intestines of *O. gachua*); shows the transformation of the *Paracamallanus* type of stoma to *Camallanus* type.

FIG. 16. Tail end of the fourth stage larva of *C. sweeti*, undergoing the fourth molt.

FIG. 17. Early fifth stage larva of *C. sweeti* (from the intestines of *O. gachua*); shows the *Camallanus* type of stoma and the longitudinal ridges at the anterior extremity, just forming.

PLATE IV

Third stage *Camallanus* larva (sp. ?) found in cyclops infected under natural conditions.

FIG. 18. General lateral view.

FIG. 19. Head, lateral view.

FIG. 20. Tail, lateral view.

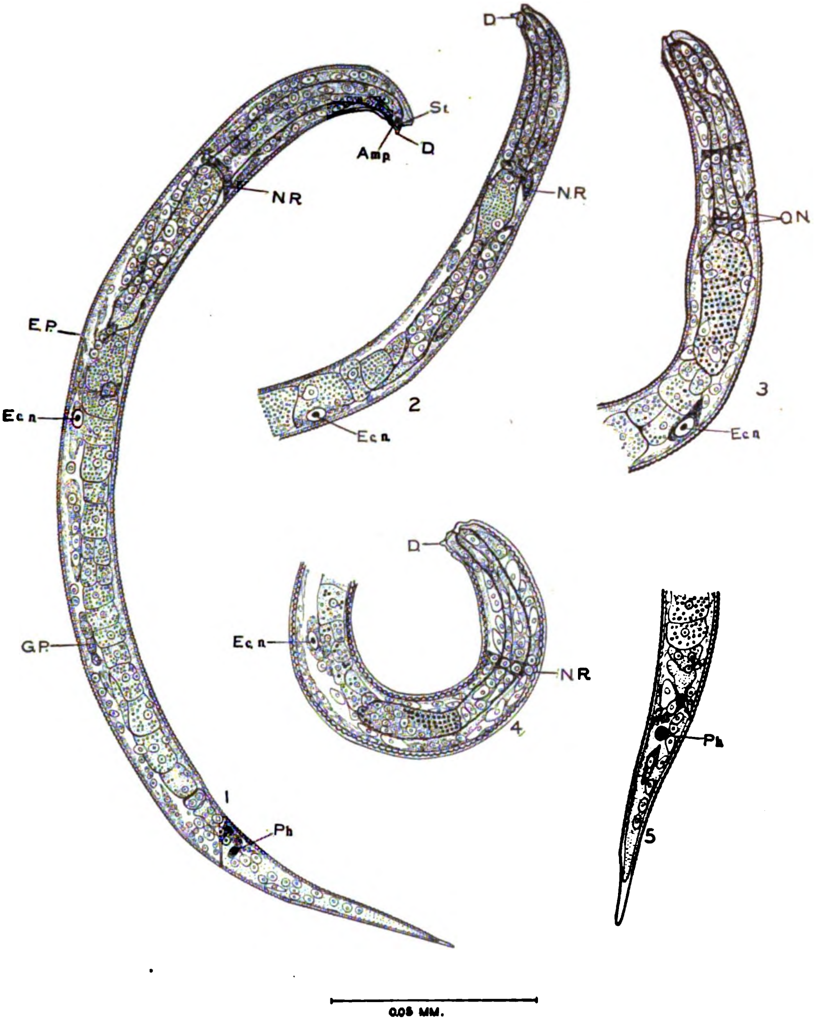


PLATE I

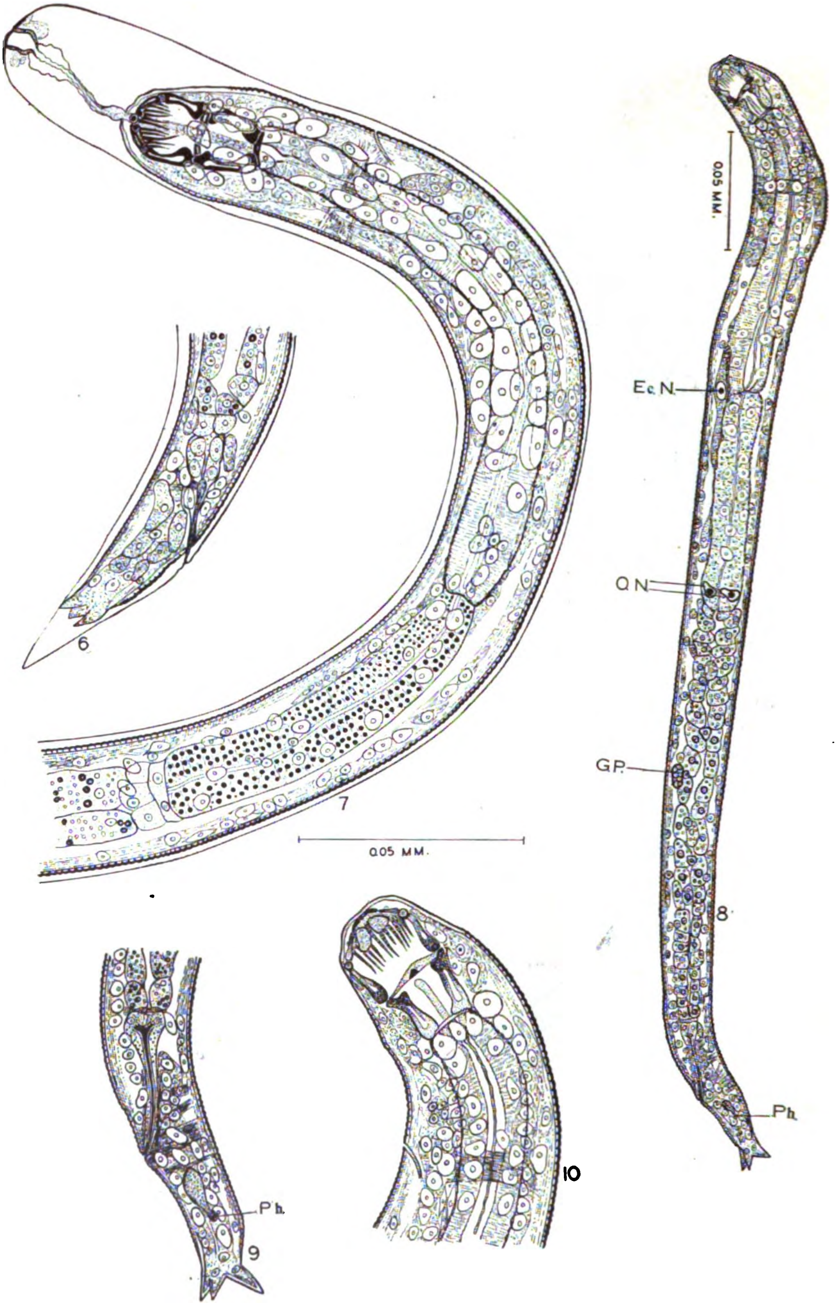


Plate II

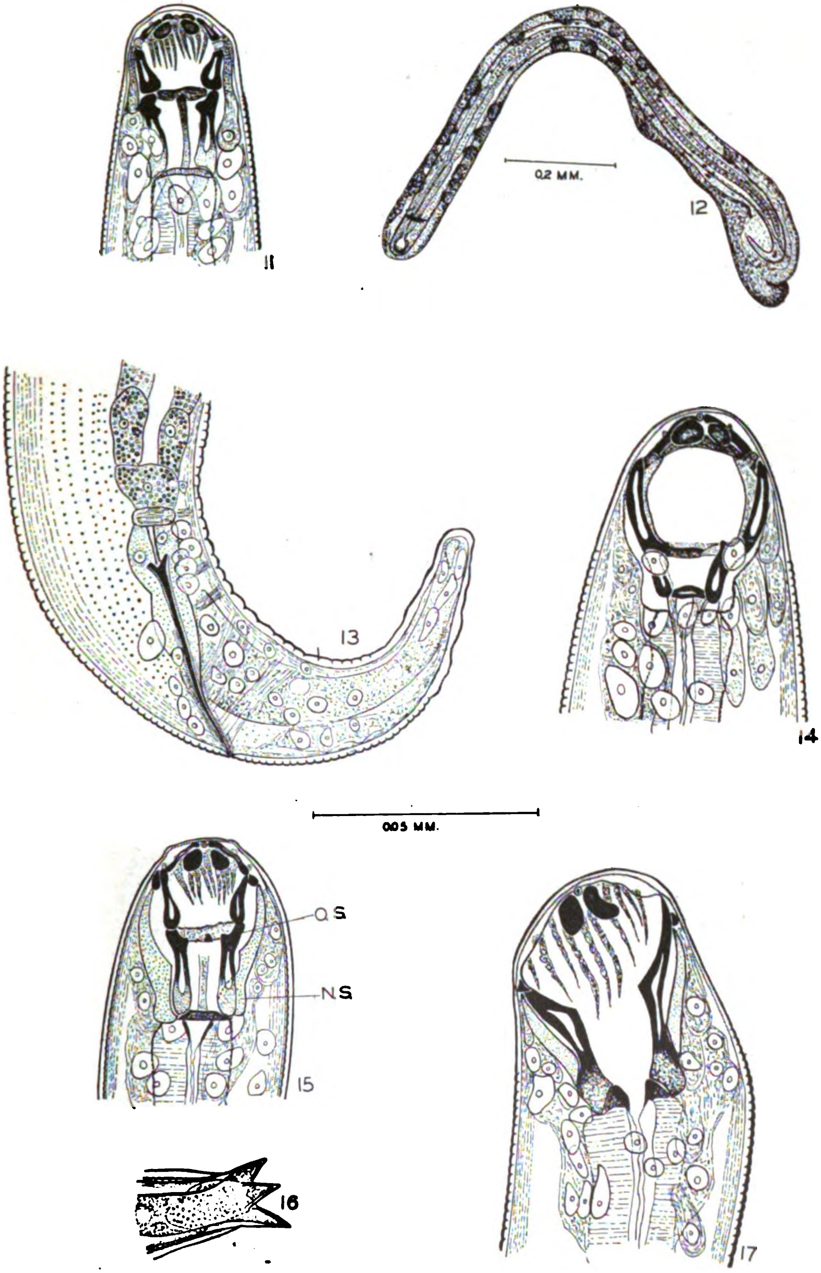
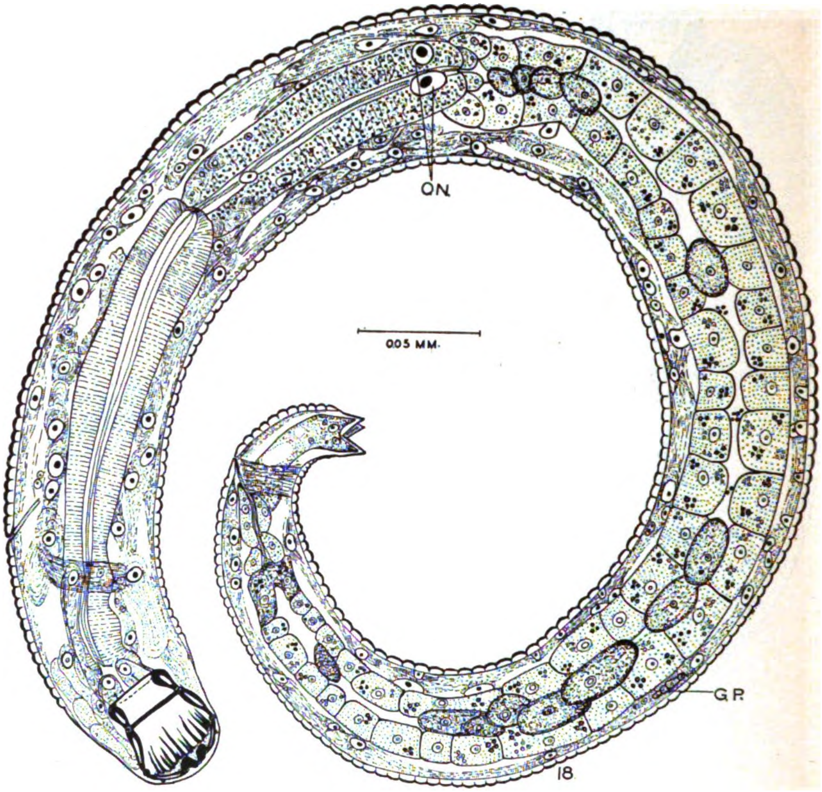


PLATE III



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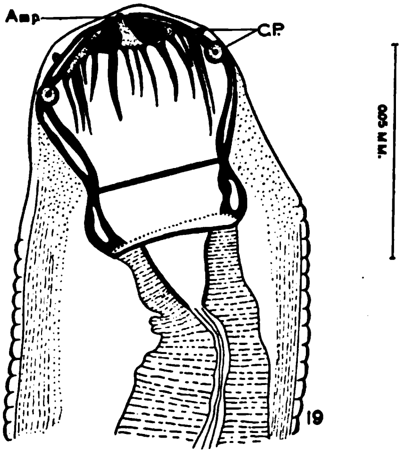

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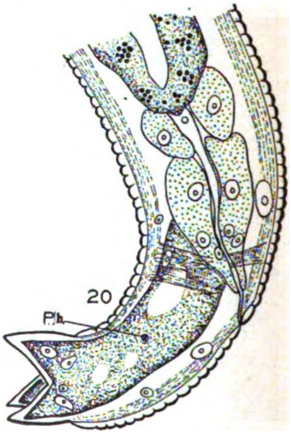

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PLATE IV

Moorthy, V. N.
and Sweet, W. C.
1936. A peculiar type of guinea-wo
Embryo.

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Ind. Jour. Med. Res., 24, 2, October, 1936.

A PECULIAR TYPE OF GUINEA-WORM EMBRYO.*

BY

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In 1931, while examining specimens of guinea-worm embryos obtained from two patients in an infected village in the Chitaldrug district, Mysore State, South India, three specimens which had a peculiar tail-end were found. Two of these were lost while making permanent slide preparations, and the one specimen left did not permit of sufficient study of structure. Subsequent to this finding all collections of guinea-worm embryos brought to the laboratory were carefully examined for further peculiar specimens but none were found until recently when a few of the embryos collected from six out of ten patients of another village proved to be of the new type. The collection was made just as the blister had burst and was consequently quite fresh. The following general observations were made :—

1. From the same worm both type A and type B embryos were obtained (Plate XXI, fig. 1).
2. Type A embryos were present in very small numbers; type B embryos were found in millions, type A being found only in hundreds.
3. Type A embryos were found in comparatively large numbers only in fresh cases for a few days after the blister was opened. When the embryos were collected by spraying the area with ethyl chloride it was noticed that type A embryos were obtained in larger numbers only in the first collection, becoming gradually reduced in number in subsequent collections.
4. As stated above, type A embryos were recovered only in six out of ten patients. In the remaining four patients, in spite of repeated careful search, they could not be found.

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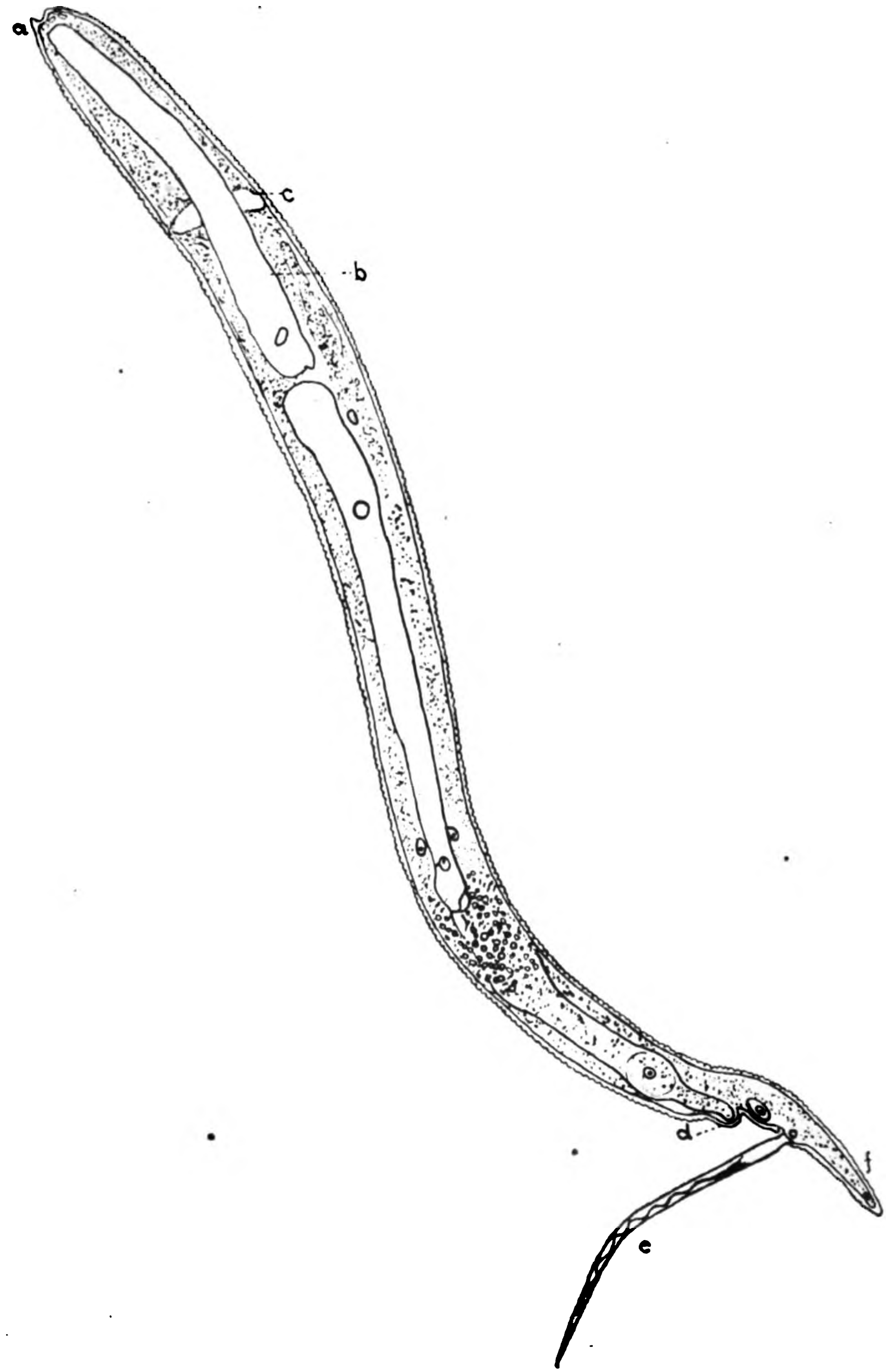
* The work here reported was done with the support and under the auspices of the Government of Mysore and the International Health Division of the Rockefeller Foundation.



TEXT-FIGURE.

Camera lucida drawing of type A guinea-worm embryo, having a peculiar posterior end with a laterally placed tail (mag. × 450).

a. Sharp-pointed, triangular projection seen in the anterior margin of the lower lip.
b. Œsophagus.
c. Nerve ring.
d. Knob-like projection.
e. Laterally placed tail.
f. Posterior narrowed portion of the embryo.

PLATE XXI.

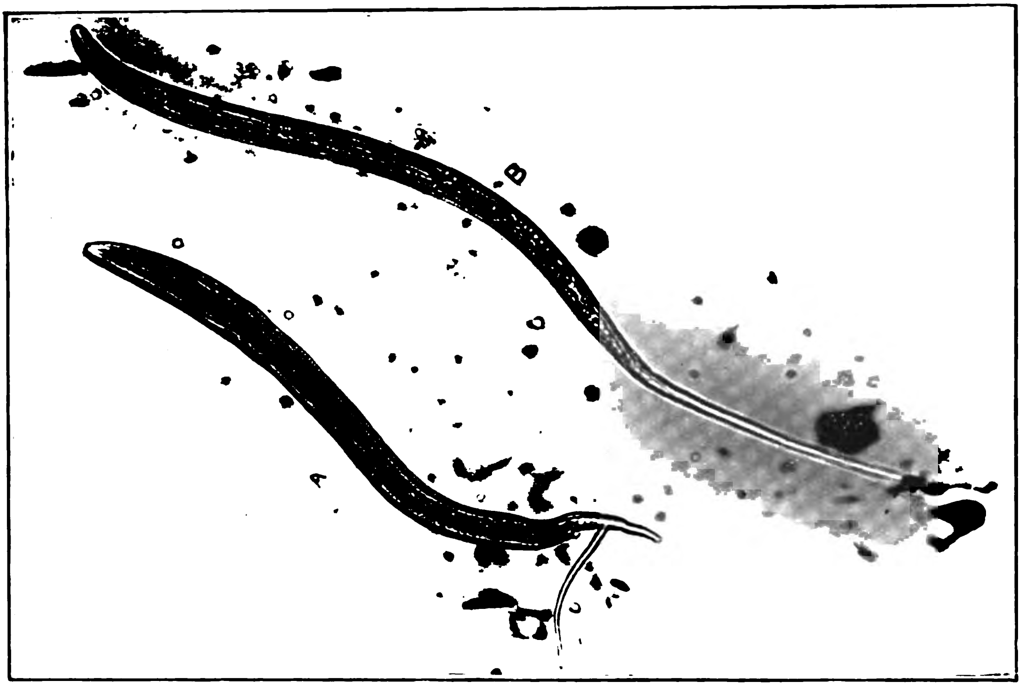


Fig. 1. *A*.—Photomicrograph of type A guinea-worm embryo (mag. × 210).
B.—Photomicrograph of type B guinea-worm embryo (mag. × 210).

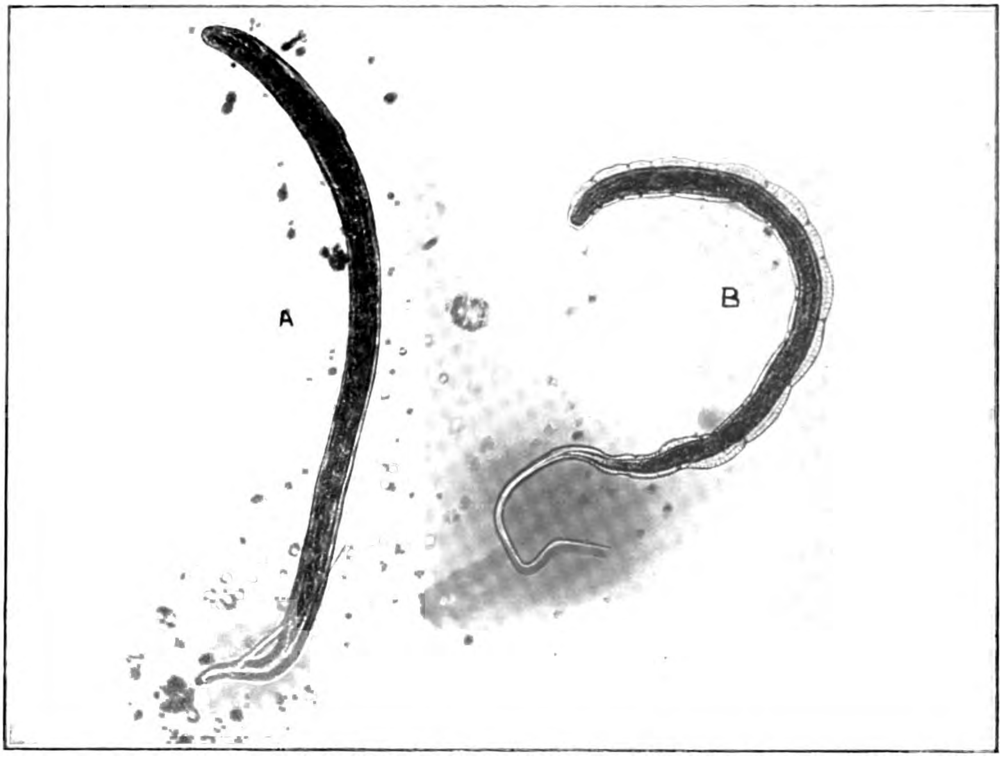


Fig. 2. *A*.—Photomicrograph of type A guinea-worm embryo just undergoing the first ecdysis in the body cavity of cyclops. Specimen dissected from an infected cyclops 5 days after infection, stained and mounted by Moorthy's method (mag. × 210).

B.—Photomicrograph of type B guinea-worm embryo just undergoing the first ecdysis in the body cavity of cyclops. Dissected from an infected cyclops 5 days after infection, stained and mounted by Moorthy's method (mag. × 210).

PLATE XXII.

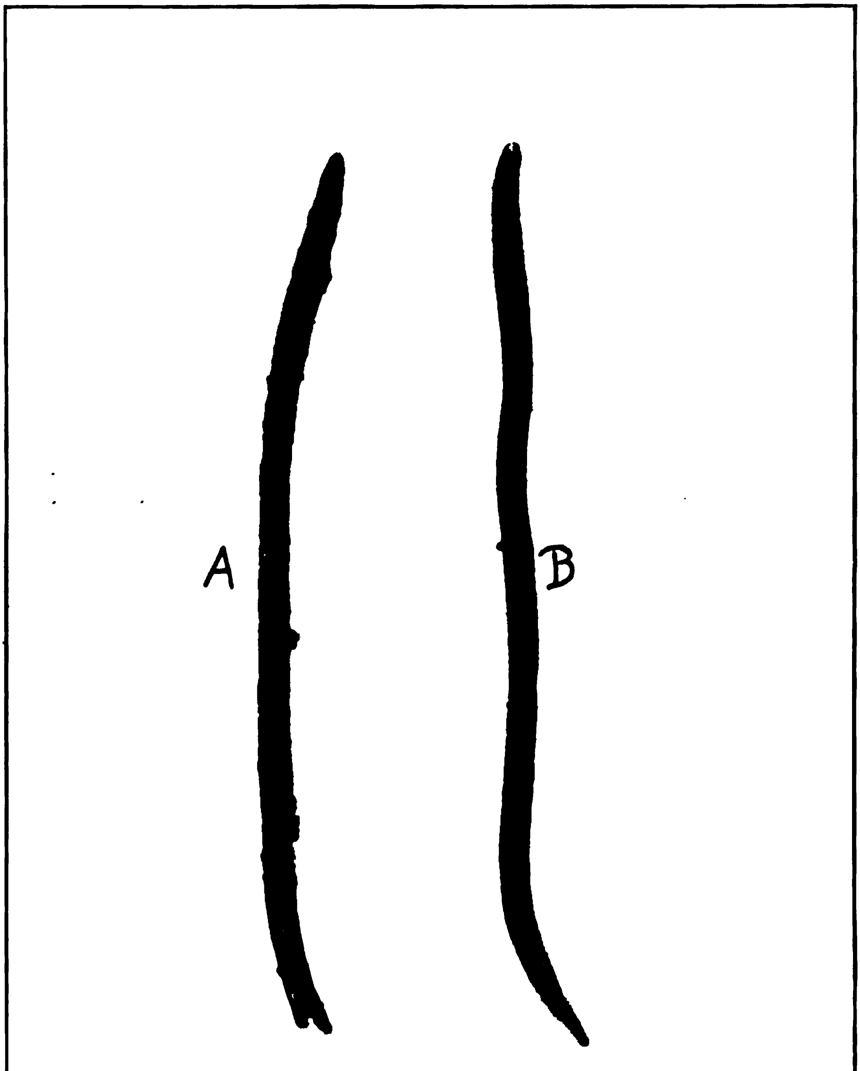


Fig. 3. *A*.—Photomicrograph of type A embryo dissected from an infected cyclops after undergoing full development in the body cavity.

B.—Photomicrograph of type B embryo dissected from an infected cyclops after undergoing full development in the body cavity.

5. A large number of cyclops were infected in the laboratory with guinea-worm embryos from one of the six patients mentioned, containing both type A and type B, and five days after infection a large number of these cyclops were dissected. The embryos undergoing developmental changes in the body cavity of the cyclops were released by dissection, fixed and stained by a special method (Moorthy, 1936). Since type A embryos were present only in small numbers, several hundred infected cyclops had to be examined to find type A embryos and to date only three of these embryos, just undergoing the first ecdysis, have been recovered. As seen in Plate XXI, fig. 2, the type A embryos carried the laterally placed tail into the body cavity of the cyclops and had not lost it until after the first ecdysis.

The type A embryo is about three-quarters the length of type B and is slightly stouter. A small triangular projection with a pointed end, resembling the small dorsal spine seen in camallanus larvæ, can be seen near the anterior margin of one of the lips. Other structures seem to be much the same as those found in type B embryos and it is only at the tail-end that a decided difference exists. In type B the tail is in continuation with the body and gradually tapers to a point, whereas in type A a characteristic knob-like structure is seen projecting to one side of the larva below which the embryo suddenly becomes very narrow. From about the middle of this narrow portion a thin tail-like structure, which ends in a sharp point, projects out laterally and is about half as long as the corresponding tail of type B. Average measurements of 20 embryos of each type, fixed and stained by the writer's method, are given :—

—	Type A, mm.	Type B, mm.
1. Total length	0·4340	0·6100
2. Breadth at the widest portion of the embryo.	0·0230	0·1624
3. Length of the œsophagus ..	0·1120	0·1358
4. Distance of the nerve ring from the mouth end.	0·0560	0·0672
5. Length of the tail ..	0·0980	0·1582
6. Distance of the knob-like structure from the mouth end.	0·3780	Not present.
7. Length of the posterior narrowed portion.	0·0560	,, ,,

Further careful search of infected cyclops revealed one specimen of a type A embryo after it had undergone its full development in the body cavity. The comparatively small number of type A embryos makes it necessary to examine literally thousands of infected cyclops. The one specimen found is shown, with a fully developed type B embryo, in Plate XXII, fig. 3. The measurements of this type A embryo, and the average measurements of ten fully developed type B embryos, were as follows:—

——	Type A, mm.	Type B, mm.
1. Total length	0·3960	0·4200
2. Breadth at widest portion ..	0·0160	0·0167
3. Distance of nerve ring from mouth end.	0·0600	0·0658
4. Distance of knob-like structure from mouth end.	0·3800	Not present.
5. Length of knob-like structure.	0·0060	„ „

From this description of the embryos it seems clear that the two embryos are distinctly different forms but that, since both have been obtained from the same adult female worm, they do not represent different species. Possible explanations of the differences are that the types are of different sexes or that the difference is a pure anatomical abnormality. Since type A embryos have been recovered in some hundreds in six different patients, it does not seem likely that the structural difference noticed is only an anatomical abnormality and so the type A embryo possibly represents one of the sexes and type B the other. As to which is the male and which the female, it is difficult to determine.

REFERENCE.

MOORTHY, V. N. (1936) .. .. 'A Simple Method of Staining and Mounting Small Nematode Larvæ' (shortly to be published).

Moorthy. V. N.

1937. A rediscription of Dracunculu
medinensis.

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pages 220–224.

A REDESCRIPTION OF *DRACUNCULUS MEDINENSIS**

Moorthy and Sweet (1936, Ind. Med. Gaz., 71: 437–442) reported on the experimental infection of dogs with *D. medinensis* and gave a preliminary description of stages (including males) encountered. To date a total of 6 pups have become successfully infected by feeding them with *Cyclops* containing larval *D. medinensis* and 45 males and 178 females have been recovered after periods of 67 to 457 days. The following table summarizes the results obtained:

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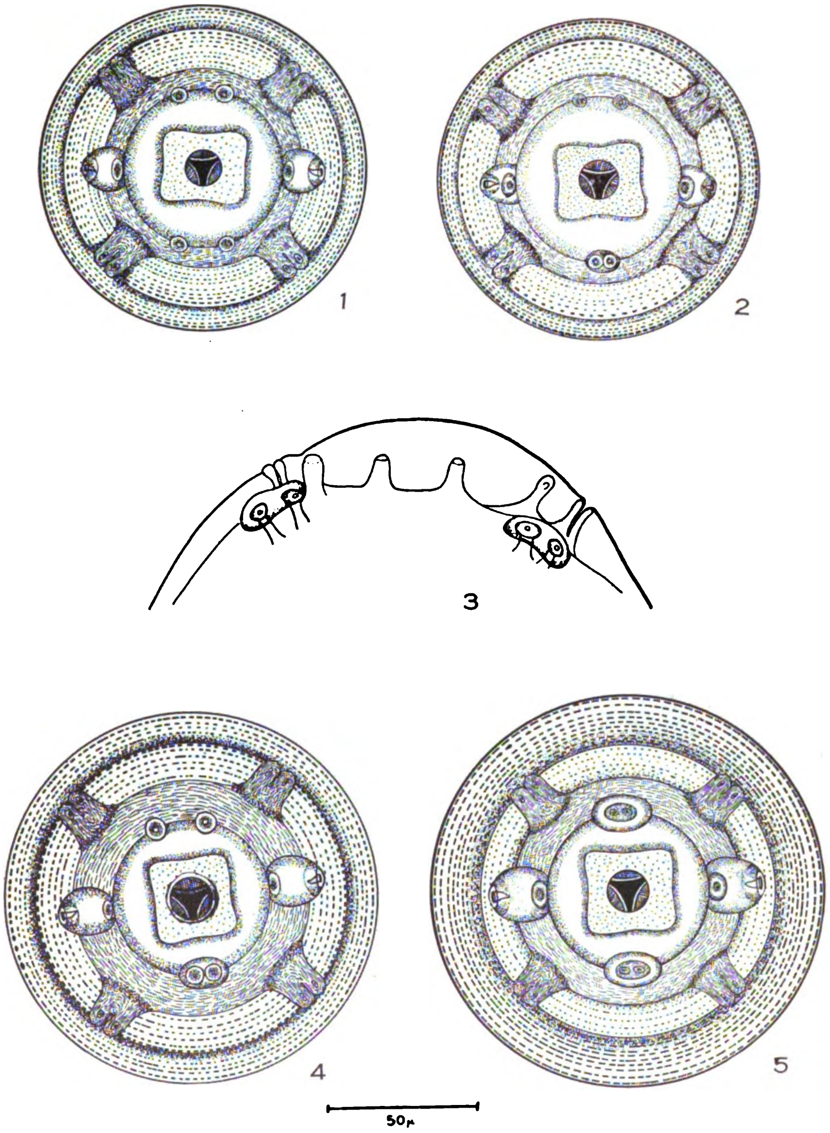
* From the Department of Helminthology, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Md.

Acknowledgment is made to the International Health Division of the Rockefeller Foundation for having granted the fellowship which made this work possible.

The writer is greatly indebted to Drs. P. A. Maplestone, P. Parthasarathy, and W. C. Sweet for the helpful criticism and advice given during the preliminary stages of this work in India. To Dr. B. Schwartz the writer's appreciation is due for the privileges of his laboratory and to Dr. B. G. Chitwood and Mrs. M. B. Chitwood, the writer wishes to express his gratitude for the very valuable help and guidance given in the course of this work.

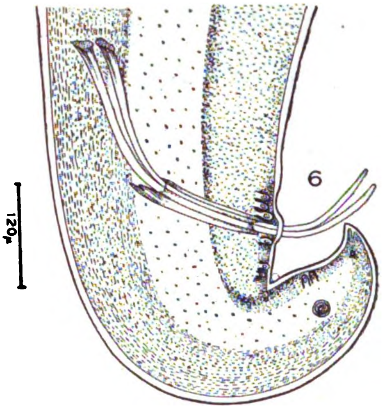
PLATE I

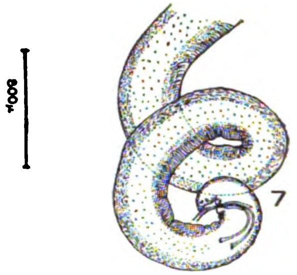


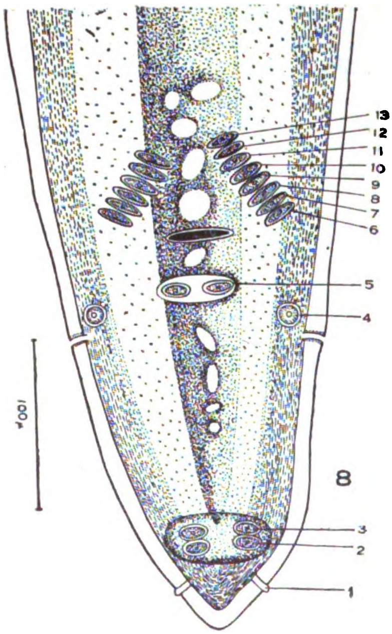
Dracunculus medinensis

Fig. 1. Male head (en face view)—interno-dorsal and interno-ventral pairs of papillae separate.
Fig. 2. Male head (en face view)—interno-dorsal papillae—separate; interno-ventral papillae—partially fused.
Fig. 3. Male head—median view.
Fig. 4. Immature female head—length 24 mm. (en face view).
Fig. 5. Mature female (en face view).

PLATE II







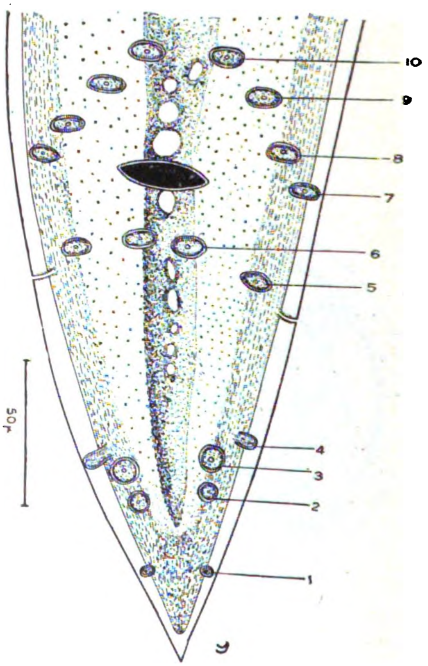
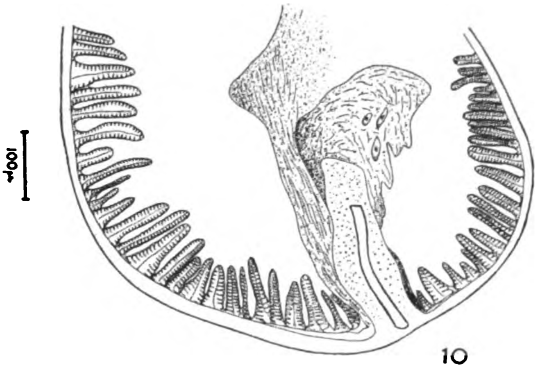


Fig. 6. Male tail (*Dracunculus medinensis*)—lateral view.
Fig. 7. Male tail (*Dracunculus medinensis*)—general view.
Fig. 8. Male tail (*Dracunculus dahomensis*)—ventral view.
Fig. 9. Male tail (*Dracunculus medinensis*)—ventral view.

PLATE III



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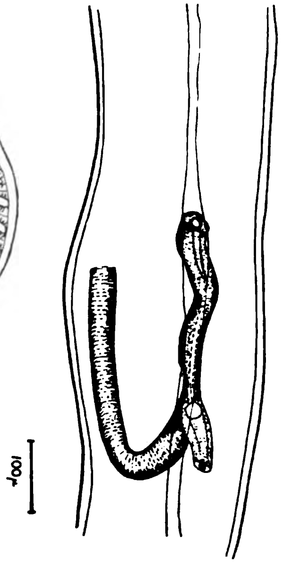

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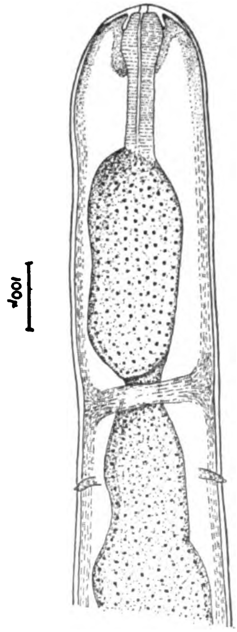

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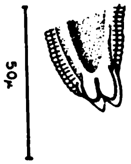

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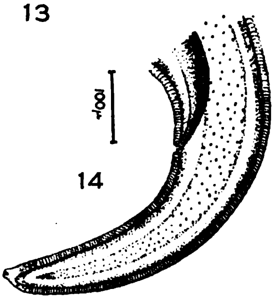

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Fig. 10. Cross section of mature female (length 31.5 cms.) in the region of the vulva showing the presence of mucoid plug.
Fig. 11. Female (length 24 mm.)—shows the vulva, vagina containing mucoid plug, and origin of uteri.
Fig. 12. Male—oesophageal region.
Fig. 13. Immature female tail (length 24 mm.) showing four caudal mucrones.
Fig. 14. Immature female (length 24 m.m.) showing the position of anus.

	Dog No. 28	Dog No. 19	Dog No. 20	Dog No. 23	Dog No. 21	Dog No. 14
No. of days after administration of infected *Cyclops*...	67	105	115	133	144	457
Number of males	7	5	17	9	7	0
Number of females	44	1	74	23	18	21
Length of males (in cms.) ..	1.2–1.8	1.8–2.4	2.0–2.2	2.1–2.9	2.0–2.9	......
Length of females (in cms.).	1.5–2.4	18	17–33	2.5–50	9–45	28–53
Larvae present	No	No	No	No	No	Yes

The following description of *Dracunculus medinensis* has been made from the study of this material.

Male.—12 to 29 mm. long by 0.4 mm. wide; oral opening minute, surrounded by an internal circle of 4–6 well-developed papillae (interno-laterals always separate, interno-dorsals and/or interno-ventrals sometimes partially fused) and an external circle of 4 double papillae (no variations); amphids posterior to interno-laterals (Figs. 1, 2, and 3); deirids (cervical papillae) slightly posterior to nerve ring (Fig. 12); oesophagus 9.6 mm. long in specimen 26 mm. long, consisting of a short anterior muscular part and a wide posterior glandular part constricted at isthmus where nerve ring is situated (Fig. 12); anus 250 µ from posterior extremity; genital papillae 10 pairs; 6 postanal and 4 preanal; numbering from the posterior extremity, pair 1 ventro-lateral; pairs 2–3 subventral, not circumscribed; pair 4 ventro-lateral near 3 and separated some distance from pairs 5–6 which are postanal, 5 being ventro-lateral and 6 subventral; 7–10 in a series from ventro-lateral to subventral just anterior to anus; phasmids lateral, posterior to pair 5. Spicules subequal, 490–730 µ long; gubernaculum 200 µ long (Figs. 6, 7 and 9).

Female.—1.5 to 53 cms. long by up to 1 mm. wide; quadrangular circumoral elevation present; oral opening surrounded by an internal circle of 4 papillae; interno-laterals separate, interno-dorsals and interno-ventrals partially fused; one large female had interno-ventrals separate; small females often similar to males (Fig. 4); external circle of 4 double papillae; amphids posterior to interno-laterals (Figs. 4 and 5); oesophagus 10 mm. long in specimen 24 mm. long. Dr. B. G. Chitwood found oesophagus 40 to 60 mm. long in specimens 75 cms. long obtained from North American mammals. Intestine pigmented in young specimens, gradually losing pigmentation with maturity. Anus 250 µ from posterior extremity in specimens 24 mm. long (Fig. 14) 900 µ in specimens 50 cm. long; tail with four caudal mucrones in young specimens (Fig. 13), without such structures in fully grown specimens. Vulva 10.3 mm. from anterior end in specimens 24 mm. long (Fig. 11). Dr. B. G. Chitwood found the vulva to be situated 14.5 cm. from the anterior end (Fig. 10) in specimens 31.5 cm. long. Vagina containing mucoid plug in specimen 24 mm. long illustrated (Fig. 11).

Apparently copulation takes place in the earlier stages of development since males were not observed after six months and the vagina contains a mucoid plug in young specimens (24 mm. long).

Dracunculus dahomensis (Neuman, 1895) is very difficult to distinguish from *D. medinensis* on the basis of the females. However, the arrangement of the genital papillae and the shape of the tail of the male (Fig. 8) provide quite satisfactory characters for the separation of these species. In this species papillae 2–3 are circumscribed; papillae 4 corresponds to 5 of *D. medinensis;* and 5 (6 of *medinensis*) is also circumscribed. The preanal papillae are apparently variable with 6–8 pairs, sometimes not all paired. *D. globocephalus* (Mackin, 1927), differs in that the spicules are markedly unequal. *D. houdemeri* Hsu, 1933, was based on a single female, the distinguishing characteristic being the cephalic pattern, the lateral cuticular elevations being trident-like. Since variations of the cephalic pattern are known in this genus, the validity of the species appears dubious.—V. N. MOORTHY, *Fellow of the Rockefeller Foundation from Mysore State Department of Health, Bangalore, India.*

Moorthy, V. N.
1938. Spinitectus corti n. sp. (Nematoda: Spiruridae).

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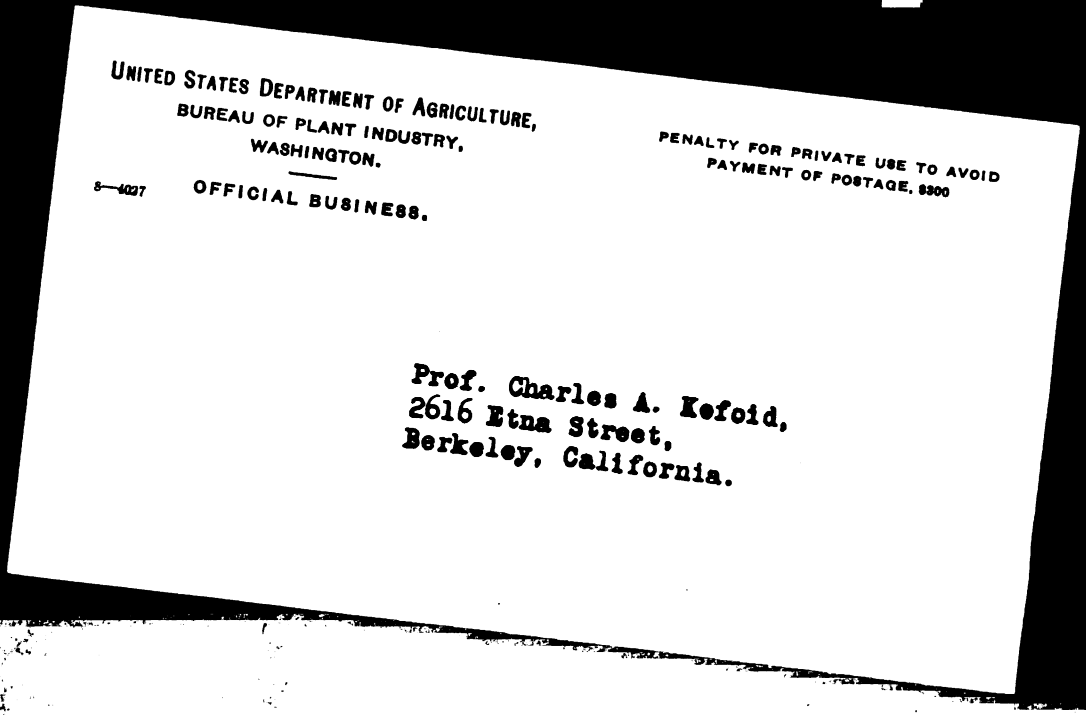

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pages 319–322.

SPINITECTUS CORTI N. SP. (NEMATODA: SPIRURIDAE)*

V. N. MOORTHY
Mysore State Department of Health, Bangalore, India

A few specimens of *Spinitectus* were obtained from the intestines of the fish, *O. gachua,* collected from the fresh-water ponds in the Chitaldrug District, Mysore State, India. This nematode appears to be a new species and for it the name *Spinitectus corti* is proposed in honor of Doctor W. W. Cort, to whom the writer is greatly indebted for the help and encouragement given.

Spinitectus corti N. SP.

(Figs. 1–4)

Description. Body filiform, widest near middle and slightly attenuated towards both extremities; anterior end bluntly conical; posterior end acutely pointed in some specimens, less so in others. Head not distinctly marked off from body. Cuticular spinous rings conspicuous, beginning about 0.07 mm from anterior end; first two rows very close together compared to other rows; total number of spinous rows varying from 45 to 51: anterior-most row contains 22 spines in a circle as observed in lateral view while in other rows the number varies from about 6 near tail to about 30 in widest portion of body; in anterior half of body spines arranged in regular circles, more posteriorly in semicircles, and in tail portion irregularly placed (fig. 1).

Female. 1.4 to 1.9 mm long by 0.14 to 0.18 mm in maximum width at middle of body. Stoma short, 0.035 to 0.040 mm long, funnel shaped. Oral opening terminal, guarded by three lips. At anterior extremity amphid and a pair of cephalic papillae present (fig. 4). Pharynx, tubular, distinct and about one-third as wide as muscular portion of esophagus. Esophagus with distinct demarcation between anterior muscular portion and posterior glandular portion; anterior muscular portion 0.13 to 0.14 mm long; posterior glandular portion, multinucleated, 0.28 to 0.37 mm long (fig. 4): esophago-intestinal valve distinct. Nerve ring 0.12 to 0.14 mm from cephalic extremity. Excretory pore at level of fourth row of spines (fig. 1). Intestine consisting of large number of cells containing yellowish brown granules and globules, and extending from about level of 10th row to 35th row of spines. Vulva situated in posterior third of

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* Contribution from the Department of Helminthology, School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.

Acknowledgment is made to the International Health Division of the Rockefeller Foundation for having granted the fellowship which made this work possible. The writer is indebted to Dr. B. Schwartz, Chief of the Zoological Division, U. S. Bureau of Animal Industry, for the privileges of working in his laboratory, and to Dr. B. G. Chitwood for valuable help and guidance.

body, close to anus, 1.23 to 1.60 mm from cephalic extremity; vagina long, muscular, extending anteriorly about 0.18 mm from vulva, and terminating at bifurcation of uterus (fig. 1). Uteri filled with eggs, occupying greater part of interior of body and extending anteriorly as far as middle of glandular portion of esophagus. Anus near caudal extremity, about level of 40th row of spines. Tail 0.10 to 0.13 mm long; in some specimens, spear-shaped and acutely pointed at tip, devoid of spines in its posterior third (fig. 2), while in others, conoid in shape, blunt and rounded at tip and spines extending to tip (fig. 3). Phasmids slightly anterior to tip of tail (fig. 2). Mature eggs in uteri and vagina, 0.028 to 0.031 mm by 0.016 to 0.018 mm, ellipsoidal, with thick transparent shells and without polar filaments.

Male. Unknown.

Habitat. Intestine of *Ophicephalus gachua.*

Locality. Chitaldrug District, Mysore State, India.

Specimen. U. S. Nat. Mus. Helm. Coll. No. 9130.

This species may be differentiated from the other species of the genus by its short stoma; its small size, being the smallest of all known species; its relatively greater width compared to length; and in having the first two rows of spines comparatively closer together than the other rows.

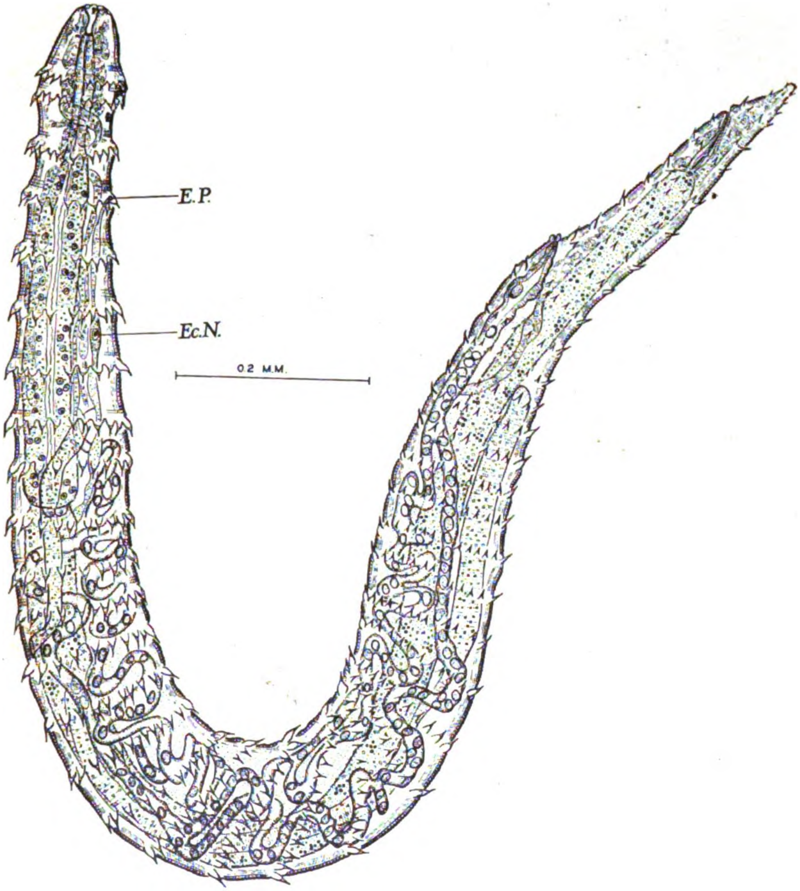

FIG. 1. *Spinitectus corti,* female, lateral view. E.P., excretory pore; Ec.N., excretory cell nucleus.

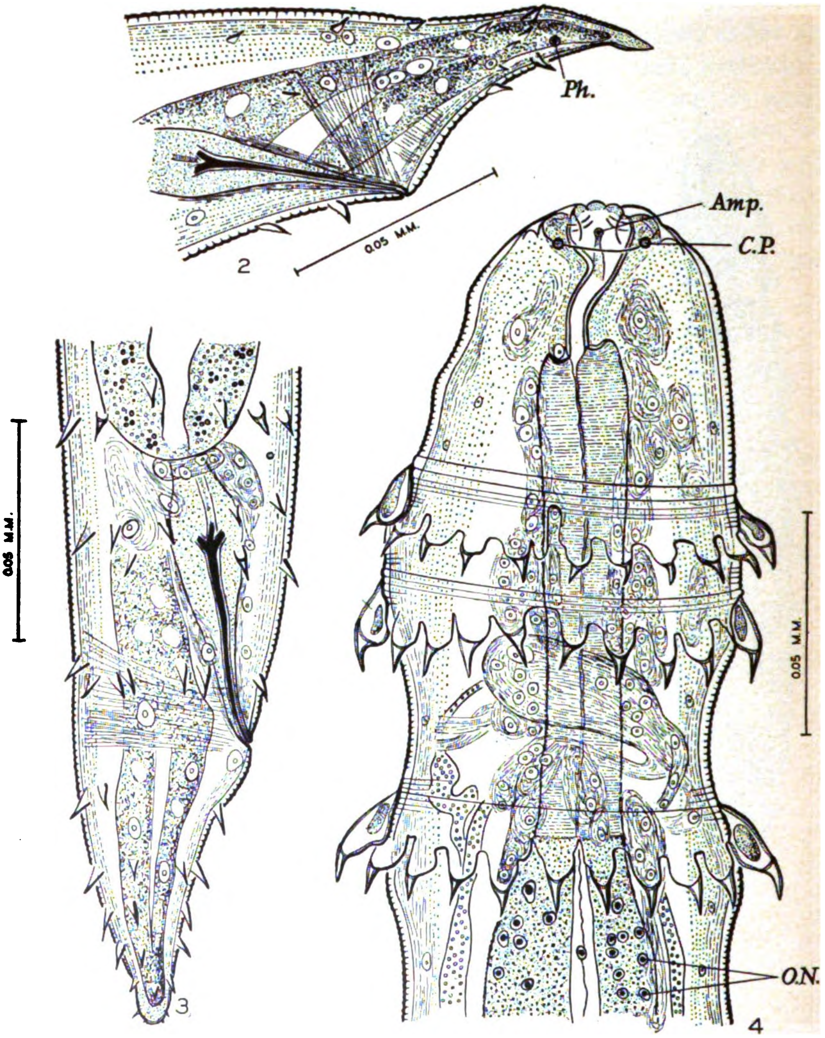

FIG. 2. Tail of female, with pointed posterior extremity; devoid of spines in the posterior region. Ph, phasmid.

FIG. 3. Tail of female, with rounded posterior extremity; spines extend to the tip of the tail.

FIG. 4. Female, esophageal region, lateral view. Amp., amphid; C.P., cervical papillae; O.N., esophageal nuclei.

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